Finance and Risk Management for International Logistics and the Supply Chain

Edited by
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CHAPTER 1

Editorial: Finance and Risk Management for International Logistics and the Supply Chain

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In today's increasingly competitive global economy, companies must not only compete on cost and price, but also on service quality. Against this backdrop, there is a growing recognition that it is through logistics and supply chain management that the twin goals of cost reduction and service enhancement can be achieved (Christopher, 1998). In an effort to reduce costs, companies build strategic partnerships, strive for just-in-time delivery, and source globally to take advantage of lower cost labor and access to raw materials. Such practices, however, have made the typical company's logistics and supply chain more complex, leading to potentially greater vulnerabilities. It is apparent that to create value through logistics and the supply chain, finance and risk management (as well as strategy, operations, marketing, and other functions) must be considered jointly.

Following the above logic, in Chapter 2, Supply Chain Finance and Risk Management: A Selective Survey and Research Agenda, Gong (2018) presents a literature review of the interrelated fields of supply chain finance (SCF) and supply chain risk management. The author identifies significant diversity within each of these fields in terms of the key concepts underpinning the disciplines, their scope, and the research methods which are utilized. A similar diversity is also identified as present within the specializations of the researchers engaged in these fields of research, where there is representation from operations management, transportation, logistics, accounting, finance, and economics. This supports and reinforces the multidisciplinary nature of both fields of research, although the author does suggest that there is a relative dearth of economic, financial, or management research in the field of supply chain

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risk management compared to the more recently emerging field of SCF. Gong (2018) goes on to identify a number of knowledge gaps which are present within both fields and sets outs a research agenda which would fill these gaps. In so doing, he advocates the continued reliance on an integrated and multidisciplinary approach to undertaking this research.

The logistics discipline has long since championed the need to look at logistics as a series of parallel flows or chains that interact and overlap. These flows are most obviously concerned with the physical flow of the cargoes themselves through a series of nodes and links that comprise the logistics infrastructure. Although other flows, most commonly of information and funds, are also emphasized, it is only in very rare cases that the academic literature has explicitly addressed how these flows might interact and overlap. In Chapter 3, Different Perspectives on Supply Chain Finance—In Search of a Holistic Approach, however, Basu Bal et al. (2018) focus specifically on the interface between physical and financial flows in logistics operations by addressing the thorny problem of how SCF solutions can be delivered to the entire supply chain. The authors build a conceptual model based on that of Liebl, Hartmann, and Feisel (2016), but extended to encompass logistical, financial, and legal aspects of the provision of SCF along the supply chain by logistics service providers. On the basis of their analysis it is concluded that, should it occur within an appropriately robust legal framework, the expansion of SCF throughout the supply chain will have significant advantages in terms of greater financial inclusion, the potential to raise small to medium-sized enterprise visibility and a general improvement in confidence and transactional efficiency that will boost the availability of capital for investment. The responsibility for developing the framework which will facilitate this rests with the collaborative efforts of policymakers, industry stakeholders and financial institutions.

A shortfall of available finance to support transactions which take place within the supply chain is not the only form of risk which can occur. In Chapter 4, Modeling Risks in Supply Chains, Sheffi (2018) analyzes and models the full gamut of potential risks which exist within supply chains. Through a number of case studies, the author attempts to identify those risks, categorize them, and assess the potential risks for supply chains. The case study approach adopted reveals that companies are frequently in a position to model the likelihood and impact of different risks on a wide range of logistics facilities, suppliers, operations, and infrastructure, but that many of these risks are buried so deeply within supply chains that they might be extraordinarily difficult to identify and evaluate. Recent trends have made logistics companies more vulnerable to the occurrence and impact of risks. These include increasing global trade, globalization and outsourcing, greater product complexity, rising global competition, lean manufacturing, natural resource constraints, and the consolidation of suppliers in some industries. Sheffi (2018) suggests that the nature of today's business environment requires that the analysis of risk within supply chains now needs to be conducted at three different levels—at company level, at supplier level, and at a deeper third level of the supply chain, whereby suppliers are impacted by the risks associated with their suppliers and other third parties. Although incredibly difficult to implement in practice, this level of detail in the analysis of risk will yield a true understanding of how disruptions arise and propagate in supply chains. Only with this understanding, will come the ability to develop optimal approaches to risk management.

International shipping is the one area of the logistics industry where the study of finance has traditionally been closely connected. As such, shipping finance represents, therefore, a mainstream theme of research work in the field. The next few chapters of this book reflect this high level of activity. In Chapter 5, The Evolution of Modern Ship Finance, Drobetz and Johns (2018) provide a comprehensive overview of the development of shipping finance from ancient times, with its origins in the financing of trade itself, until the sophistication of today's shipping finance arena. The authors' historical analysis reveals how the operation of ships has evolved over the centuries and how this has been linked to the development and use of different financial strategies and instruments. Because of the intertwining of personal and public interests together with the sources of finance, all taking place in a market context where distortions created by direct and indirect government intervention are common, the authors conclude that ship finance is quite a distinct discipline where, despite the considerable risk and volatility involved, the different available methods and strategies for dealing with this do not conform with the standard "rules" of corporate finance. They further suggest, in fact, that the level of complexity which pervades the financing of shipping has resulted in a systematic underpricing of the risks involved and that this characteristic may be an antecedent of the consistent overbuilding in many shipping markets, the relative dearth of representation on public capital markets and why structured investments have proven difficult to market. The chapter ends by highlighting the potential for the greater proliferation of more structured financing models for ships given the recent continued absorption of shipping, particularly in terms of ownership, into the wider supply chain.

Moving to contemporary questions in shipping finance, Chapter 6, Investor Sentiment, Earnings Growth, and Volatility: Strategies for Finance in International Shipping, by Pouliasis et al. (2018) focuses on the influence of investor sentiment in the dry bulk shipping sector. Acknowledging that the international maritime logistics industry is characterized by significant volatility in freight rates, the authors hypothesize that having a measure of the sentiment of the investors involved in the industry can provide significant advantages in terms of formulating market expectations, asset valuation, generating industry entry (buy), and exit (sell) signals, as well as potentially increasing liquidity. The authors test their hypothesis through an empirical analysis of the relationship between investor sentiment and vessel earnings. The results of the analysis indicate that market sentiment exerts a statistically significant effect on the conditional mean and variance of market earnings growth rates, with fluctuations in earnings being driven by shocks to the sentiment level and volatility. In addition, a further investigation of the lead—lag relationship between investor sentiment, earnings, and their respective volatilities reveals the existence of a two-way feedback relationship between sentiment and vessel earnings. The authors conclude, therefore, by pointing to the possibility of using measures of investor sentiment (i.e., changes in the level of market optimism or pessimism) to predict earnings and volatility in shipping markets. This will yield significant advantages, not only in terms of industry players making better investment decisions, but also for policymakers in their efforts to facilitate trade by reducing the level of price volatility in what is a critically important element of transport costs.

Motivated by the impact of the 2008 financial crisis, Gounopoulos and Paltalidis (2018) (Chapter 7: Tail Risks in Credit, Commodity and Shipping Markets) investigate the presence of dependence between shipping markets and the more generic financial, commodity, and credit markets, in order to determine the extent to which shocks to stock, commodity, and credit markets are transmitted to the shipping markets. Uniquely, the authors apply three copula functions with different dependence structures to measuring the conditional and tail dependence between the main shipping indices and indices of prices in the stock, commodity, and credit markets. The empirical analysis reveals that significant and symmetric lower tail dependence exists during periods of financial crisis, but that lower tail dependence exceeds conditional upper tail dependence. The results imply that (1) during periods of economic turbulence, dependence increases and generic financial crises will quickly spread to shipping markets, causing asymmetric contagion which advances as market downturns deepen and (2) during periods of general economic recovery, the level of dependence drops and the shipping markets become sluggish in mirroring the speed of general economic recovery. All this implies some form of hysteresis effect in the relationship between the major shipping market indices and generic economic indicators in that these markets will crash together but recover independently. The analysis also reveals that the dry bulk market is more susceptible to these downside risks and contagion than the tanker market, as are the markets for larger ships compared to medium-sized vessels. By capturing the source and the transmission channel by which price volatility in the shipping markets are amplified, the research reported within this work has important ramifications for the evaluation of risk, hedging strategies, and asset pricing.

A major strand of current research in the field of logistics and supply chain management is concerned with securing improved environmental performance, mainly in the transportation arena. Whatever the available operational or technological possibilities for achieving this, in almost all cases a significant investment of capital will undoubtedly be required and, of course, this will involve having recourse to suitable sources of finance. In Chapter 8, Financing Ships of Innovative Technology, Schinas (2018) considers this issue from the perspective of the financing required specifically for technically advanced and innovative technology in the shipping industry. The traditional mainstream source of finance for shipping has been debt. Since the financial crisis of 2008, this has understandably become more difficult to obtain, mainly because of a more stringent regulatory regime faced by the banking sector. At the same time, because ships have had to achieve compliance with the continuously emerging environmental regulations, the demand for additional finance to meet the increased costs of doing so has significantly increased. Quite apart from the inherent risk of innovation, ships that have better environmental credentials will have a cost premium that translates into a higher required freight rate (RFR) than competing conventional ships. In order to overcome the potential problems this higher RFR might pose in the short to medium term, the author suggests that unconventional financial options should be considered and advocates both export credits and leasing in this respect. The cases of LNG-fueled ships and fully autonomous ships are used as practical examples of innovation to illustrate how these concepts might play out in practice. In conclusion, the author asserts that the adoption and successful implementation of technical innovation in shipping will depend on financial innovation and the extent to which novel approaches, methods, and techniques emerge as the "new normal."

The final few chapters comprise applied case studies which illustrate the general theme of the book as a whole. The first of these focuses on the cooperative movement. The cooperative as a form of business organization has been around a long time (Balnave & Patmore, 2017) and is now widely applied across numerous countries and industries. It should be recognized, however, that over the years the operating practices and capital structures of cooperatives have evolved to meet the needs of the contemporary business environment. In Chapter 9, Operational and Financial Management in Agricultural Cooperatives, Qian and Olsen (2018) identify the common features of cooperatives, irrespective of sector or size, which distinguish them from other forms of business organization. Among a number of singular characteristics, cooperatives are most critically and uniquely differentiated by the feature that "...those who transact with (patronize) the organization also own and formally control the organization" (Evans & Meade, 2005). The authors also highlight the fact that ownership and control by cooperative members, as well as the distribution of profits, are uniquely based on patronage (i.e., a member's won economic transactions with the cooperative organization) rather than, for example, the value of capital invested in the organization. The operational practices of cooperatives are illustrated by analyzing two case studies of agricultural cooperatives (for kiwi fruit and dairy products) that are owned, controlled, and invested in by a group of farmers who collaborate by pooling resources for their mutual benefit. In so doing, the authors pay particular attention to quality management, payment schemes, financial management, and capital structure innovations.

Chapter 10, Cold-Chain Systems in China and Value-Chain Analysis, by Wang and Yip (2018) also has a focus on agricultural supply chains, as well as the supply chains for frozen processed foods and pharmaceutical products, with their analysis of the rapidly emerging market in cold-chain systems in China. Driven mainly by a growing desire for high-quality food by end-consumers and for better quality assurance from food businesses, the demand for chilled and frozen consumer products within China is burgeoning. However, in 2008, a melamine contamination of milk which caused six infant deaths (Chan & Lai, 2009) and a vaccine scandal in 2016 (Wang & Burkitt, 2016) have undermined public confidence in the ability of China's cold-chain systems to ensure the quality and safety of products during the distribution process. The authors apply value-chain analysis to the examination of the supply chain structures of three different cold-chain products and then analyze the integration strategies of China's three leading cold-chain service providers. Proposals are then formulated not only for improving the performance of the cold chains on the basis of supplier relationships, but also for government policy and setting the direction for the cold-chain industry in China.

The focus of Chapter 11, Choosing Cross-Border Financial Guarantee Instruments—Economic Implications and Hidden Risks, is on the tariffs, taxes, duties, and fees that are imposed on transport carriers for moving cross-border cargoes. Urciuoli et al. (2018) analyze the financial, operational, and security implications associated with the temporary suspension of these charges on cross-border movements. Through the use of an illustrative case study based around an intermodal cargo movement (road and sea) routed via five countries—Serbia, Bulgaria, Turkey, Georgia, and Azerbaijan—the authors reveal the variety of methods and financial instruments which transport carriers have at their disposal for financing the temporary suspension of taxes and duties. The authors go on to analyze how these different approaches impact the carrier's business, particularly with respect to the security and operational risks associated with cross-border or transit operations, and to evaluate the relative levels of profitability associated with each of the available options.

Investments in port locations not only facilitate the logistical movements that support international trade, but also play a vital role in regional economic development. With this in mind, free economic zones (FEZs) have often been implemented in port locations in order to foster regional economic activity by attracting business activities and investment into port cities (Song, 2015; Xing, 2014). With exactly these intentions in mind, South Korea has established a number of FEZs in its largest port cities. In the penultimate chapter of the book (Chapter 12: Regional Effects of Port Free Economic Zones on Real Estate Speculation: A Korean Case Study), Cocconcelli and Medda (2018) investigate whether the creation of FEZs in the country's major port cities may have prompted irrational speculative behavior in real estate markets that has had an impact on the main indicators of regional economic activity and largely undermined the potential long-term anticipated benefits of the FEZ. The results of the quantitative analysis point to the presence of speculative behavior in FEZ cities, most notably in the multipurpose port of Incheon, and that this has exerted a negative effect on port development and FEZ performance. The authors conclude that while FEZs have the potential to deliver economic benefits to the region, they should be tailored to fit the characteristics of each port location in which they are established.

As with the international shipping industry, the risks faced by firms operating in the airline sector are substantial. Capital costs are high and operating across a truly international arena means currency risk exposure is a constant consideration. Both shipping and airlines also face significant risks with respect to the price volatility of fuel. The final chapter of the book (Chapter 13: Risk Management in the Airline Industry) by Pyke and Sibdari (2018) deals with the issue of risk management in the airline industry. Although addressing primarily the passenger airline sector, the transportation of freight by air is so closely intertwined with passenger transport, it is difficult (if not impossible) to focus solely on the risks associated exclusively with the logistics function of air transport. In any case, the risks that are faced and the approaches to their management are virtually the same for both pure passenger and pure freight carriers, with the exception that they respectively take place within a B2C and a B2B context. At the interface, where airlines provide both passenger and logistics transport, the approach to risk management has necessarily to be integrated across both types of service provision. This chapter begins by delineating the risks that are faced by airlines and the tools (such as leasing contracts, currency hedging, fuel price hedging, capacity management, and revenue management) that are used for managing these risks. The authors report the results of an empirical study which reveals how seven US airlines respond to the fluctuations in fuel cost, passenger demand, and unemployment rate, by adjusting flight frequency, aircraft size, and load factors (via changes in pricing). Empirical observation also reveals that airlines make risk management decisions on capacity, hedging, and pricing within a decentralized structure, rather than in an integrated way. In line with Pyke, Shi, Sibdari, and Xiao (2017), where the benefits that can accrue to an airline that integrates these three decisions are outlined, the authors outline a normative analytical model for integrated risk management which could form the basis for advancing the ability of airlines to manage risks in a truly integrated way.

It is our hope that the collection of chapters in this book provides a point of reference and "food for thought" to researchers, practitioners, and other stakeholders interested in logistics and supply chain management.

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CHAPTER 2

Supply Chain Finance and Risk Management: A Selective Survey and Research Agenda

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2.1 INTRODUCTION

The objectives of this chapter are to identify gaps in our knowledge of supply chain finance (SCF) and risk management, provide a source of reference for research frameworks, and outline an agenda for future research. I begin by conducting a literature review. To find articles (including review articles) related to supply chain risk management (SCRM), a key word search is conducted using various library electronic databases (e.g., Web of Science, EBSCOhost, ProQuest) for articles containing the words "supply chain," "supply," or "supplier" in combination with "risk," "vulnerability," or "disruption" in their titles or abstracts. After locating an article, I check the references for related articles and trace articles that have cited a given article. These electronic searches are supplemented by reading books and book chapters dedicated to logistics and supply chain management (SCM) (e.g., Christopher, 2014, 2016; Chopra & Meindl, 2016). The foregoing process brings up thousands of journal articles (before discarding multiple occurrences of the same article). To make the task manageable, the sample period is restricted to start from 2003.[1] I first read through literature review articles dedicated to SCRM (e.g., Ho, Zheng, Yildiz, & Talluri, 2015; Jüttner, 2005; Jüttner, Peck, & Christopher, 2003; Sodhi, Son, & Tang, 2012) and then stand-alone articles in major journals in SCM, logistics, and operations management (plus other journals if deemed relevant) that study this issue from a

[1] Jüttner, Peck, and Christopher (2003) is one of the earliest review papers on supply chain risk management. Studies of supply chain finance, on the other hand, are relatively more recent (Rogers, Leuschner, & Choi, 2016). Thus by setting the start year to 2003, it is believed that most papers will be included.

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conceptual, empirical (including case studies and surveys), experimental, or theoretical perspective. Finally, the gaps in knowledge are identified, and avenues for future research are discussed.

A similar approach is adopted to find articles related to SCF. The process brings up a much smaller number of articles, reflecting the relative dearth of such studies. I identify the gaps in the SCF literature by referring to the typical breakdown of corporate finance (Ross, Westerfield, Jaffe, & Jordan, 2016) into three main topic areas: capital investment decision, sources and costs of long-term financing, and short-term finance. In so doing, I depart from many existing studies of SCF, which tend to focus on working capital management only (Gelsomino, Mangiaracina, Perego, & Tumino, 2016; Rogers et al., 2016).

Although the discussions are divided into SCF and SCRM, they are interrelated—in many cases, supply chain financing and governance arrangements are ways of managing risks in the supply chain (e.g., Tunca & Zhu, 2017). However, for better organization and ease of exposition, I separate the literature review and discussions into these two topics. Rather than enumerating, categorizing, and summarizing the articles identified, I focus on discussing what existing studies have *not* yet done, without detailing what they have each done, though brief discussions of select papers are provided as a link to the avenues for future research.

2.2 SUPPLY CHAIN FINANCE: WHAT IS IT, AND WHAT DO WE (NOT) KNOW?

2.2.1 Definition and Scope of Supply Chain Finance

The rising interest in SCF is in no small part attributed to the credit crunch caused by the Global Financial Crisis that broke out in 2008, though more and more companies are taking a holistic and long-term view of the potential benefits that SCF can offer (Rogers et al., 2016). Gelsomino et al. (2016) identify 119 papers on SCF published from 2000 to 2014 in international peer-reviewed journals and in the proceedings of international conferences. These studies have approached SCF from two major perspectives: the "finance oriented" perspective that focuses on short-term solutions provided by financial institutions addressing accounts payable and accounts receivable, and the "supply chain oriented" perspective that focuses on working capital optimization, either within the company or for multiple supply chain participants. More recent examples of the former type of studies include Hoberg, Protopappa-Sieke, and

Steinker (2017) and Song, Yu, and Lu (2018). Recent examples of the latter type include Lekkakos and Serrano (2016) and Larsen and Jacobsen (2016).

Rogers et al. (2016) discuss the scope of SCF as it is being used in academic research and industry practice. In their view, "Supply chain financing is using the supply chain to fund the organization, and using the organization to fund the supply chain." (p. 7) They recognize that SCF involves utilizing the supply chain to develop savings, generate profits, and efficiently manage assets to fund the firm. To illustrate how SCF works, they describe several supply chain financing programs (e.g., trade finance, reverse factoring, dynamic discounting), types of firms providing supply chain financing services (banks, Fintech companies) and important issues affecting supply chain financing (regulation, accounting treatment). While studies such as Rogers et al. (2016) provide good discussions of the definition and scope of SCF and the enabling/limiting factors affecting the development of SCF, most existing studies of SCF have focused on working capital management. In my view, such a narrow perspective limits the contributions that SCM and finance researchers can make to the theory and practice of SCF.

Finance focuses on studying three main questions: (1) The capital investment (capital budgeting) decision: In what long-lived assets should the firm invest? (2) The long-term financing decision: How can the firm raise money for the required capital expenditures? (3) Short-term finance (working capital management): How should short-term operating cash flows be managed? In principle SCF is no different from traditional corporate finance: in both cases, the goal is to add value for the business owners. Supply chain decisions affect the firm's capital structure, risk level, cost structure, profitability, and ultimately market value (Gomm, 2010); in turn, finance decisions also affect supply chain operations (Birge, 2015; Kouvelis & Zhao, 2017; Strieborny & Kukenova, 2016). Nevertheless, SCF (broadly defined) has several features that distinguish it from traditional corporate finance. First, the SCF literature tends to emphasize SCF as a combination of products, services, and technology solutions that often involve a financial institution (Gelsomino et al., 2016). Such an emphasis leads many SCF studies to focus on working capital management techniques (e.g., inventory management, trade credit) and the roles of technology and financial intermediaries in SCF.

Second, in contrast to the "inward looking" perspective in traditional corporate finance whereby financial management is examined from a focal firm's standpoint, SCF takes an "outward looking," or stakeholder perspective and explicitly recognizes the interactions (in terms of physical flow, information flow, and cash flow) among multiple supply chain participants. Such interconnectedness between two or more organizations in a supply chain, emphasized by many authors in their definition and scope of SCF (Hofmann, 2005; Pfohl & Gomm, 2009), presents special challenges to the investment in and financing of (shared) assets.

Despite the abovementioned differences, as a well-developed academic discipline, corporate finance can inform SCF research and practice. Similarly, SCF can extend and enrich corporate finance research and practice. In the following sections, I discuss the existing SCF literature within the framework of the three main topics of corporate finance.

2.2.2 Capital Investment in Supply Chains

The literature search reveals very limited research on the decision-making process and efficiency of capital investments in supply chains. One way to examine the process and efficiency of capital budgeting is to inquire into what investment appraisal techniques (e.g., net present value (NPV), internal rate of return, payback period) are used by supply chain professionals in their capital investment decisions, and whether these techniques are used correctly.[2] A second way to examine the efficacy of investment decisions is to gauge the quality of the cash flow estimates and the accuracy of the cost of capital estimate (see more discussions later). Yet another way to study the capital investment decision is to probe into the question of whether all positive NPV projects (growth opportunities) are invested in.[3] To my knowledge, there is almost no research into these issues. Given that value is created primarily from efficient investments (as opposed to clever financing, which is rare in an informationally efficient capital market), the lack of interest in, and research into these important issues is surprising. In part, this may reflect a silo mentality in which supply chain managers and finance managers make decisions independently.

[2] See finance textbooks (Ross et al., 2016) for details on capital budgeting techniques and how they should be used.

[3] Responsiveness of investment to growth opportunities, alternatively called Q sensitivity of investment, is commonly used in the finance literature (e.g., Hubbard, 1998; Stein, 2003; Mclean, Zhang, & Zhao, 2012) as a measure of investment efficiency.

Another contributing factor is that academic research has been organized into distinct disciplines (e.g., SCM, finance), leading to fragmented research fields.

A small number of papers have shed light on the value of major investments in supply chains. Dehning, Richardson, and Zmud (2007) examine the financial performance effects of information technology investments in SCM systems in 123 US manufacturing firms using audited financial statements. They find that SCM systems increase gross margin, inventory turnover, market share, and return on sales, and reduce selling, general, and administrative expenses. The performance effects vary across industry (stronger for high-tech firms) and depend on the scope of the SCM implementation (stronger for incremental approach than "big bang" approach projects). These results are of relevance to researchers and practitioners in evaluating what types of supply chain investments may create value and under what conditions.

Filbeck, Kumar, Liu, and Zhao (2016) examine the effect of supply chain disruptions on American and Japanese auto companies (as well as their competitors). They document that a supply chain disruption, on average, reduces shareholder value by about 1%. Using stock market capitalization, they estimate that a successful investment in supply chain disruption prevention could save $312 million for GM and $1370 million for Toyota.

If investing in good projects (including assets and capabilities) creates value, failing to invest may destroy value. Using an event-study methodology, Hendricks and Singhal (2003) find that supply chain glitches such as production and shipment delays decrease firm value by an average of 10.28%.[4] Hendricks and Singhal (2005) analyze the impact of supply chain glitches on operating performance and find that the glitches lead to 6.92% lower sales growth, 10.66% increases in costs, and 13.88% increases in inventories, compared to control firms matched by size and industry.

The result in these studies highlights the value of investing in effective SCM and underscores the need for conducting correct investment analysis and securing adequate financing for all worthy investments in the supply chain.

[4] See Gong (2009) for discussion of the event-study methodology and applications to the transport industry.

2.2.3 Long-Term Financing of Supply Chain Investments

The long-term financing decision centers on choosing the most suitable (in terms of both costs and maturity) source of financing for the required capital expenditures. Long-term financing can come from equity, debt, or a combination of equity and debt. The choice of equity and debt is known as the capital structure decision. In traditional corporate finance (e.g., Ross et al., 2016), an optimal capital structure balances the benefits of borrowing (primarily in the form of tax savings) against the costs of borrowing (including financial distress cost). On the other hand, Williamson (1988) views debt and equity as alternative governance structures rather than alternative financial instruments and argues that whether a project should be financed by debt or by equity depends principally on the characteristics of the transaction (e.g., asset specificity).[5]

One basic principle in finance is that the cost of capital (required return) depends on the use to which the capital is put, as opposed to the source of the financing (Ross et al., 2016). In other words, even if the company is able to borrow at a cost of say 3% per year, if it invests the money in a high-risk project, the required return is not just the (after-tax) cost of borrowing; instead, it depends on the risk of the cash flows generated from that project. Thus, to determine the cost of capital, one must determine the risk (more precisely, the systematic risk) of the specific project.[6] To the best of my knowledge, there is no published study yet on whether and how companies determine the systematic risk of, and hence the required return for, a supply chain investment. My conjecture is that companies use the firm-level weighted average cost of capital (WACC) as the required return to most (if not all) of their investments. The fallacy of such an approach has been well illustrated in textbooks, though recent empirical studies (e.g., Krüger, Landier, & Thesmar, 2015)

[5] Williamson (1988) advocates a project financing approach that makes each transaction the basic unit of analysis. The central imperative is to align transactions (be they for intermediate product, labor, finance, final product, etc.), which differ in their attributes (including asset specificity), with governance structures, which differ in their costs and competencies, in a discriminating way that is transaction cost economizing. See Williamson (2008) for an application of transaction cost economics (TCE) to supply chain management. Gong, Firth, and Cullinane (2016) apply the TCE approach to analyze the financing of the transport industry.

[6] The literature has recognized the need to distinguish between systematic risks that depend on market-wide factors from risks that are idiosyncratic (Birge, 2015), and to apply a "risk adjustment" in the evaluation of supply chain activities (Gomm, 2010), though there is little empirical evidence on whether and how this is done in practice.

still find that conglomerates use a single within-firm discount rate (WACC) for investment decision-making, leading to underinvestment (overinvestment) in relatively safe (risky) divisions and consequently value loss. Given that the modern supply chain involves very different types of assets/activities/players that may have different levels of (systematic) risk and investment horizons, it remains to be determined whether supply chain investments are guided by application of the correct finance principles in terms of the choice of financing methods and the relative costs of the different financing methods.[7]

2.2.4 Short-Term Financing for Supply Chains

The SCF literature has paid considerable attention to short-term finance, to the extent that SCF and working capital management are often used synonymously by many authors (Rogers et al., 2016). Rather than illustrate the workings of short-term SCF instruments (for illustrations, see Rogers et al., 2016) or reviewing the older SCF literature (see Gelsomino et al., 2016), in what follows I discuss a few more recent studies that are deemed to be most relevant to the purpose of this chapter.

Caniato, Gelsomino, Perego, and Ronchi (2016) examine the objectives leading to the adoption of SCF solutions that optimize firms' working capital, using 14 cases of Italian companies. Based on interviews with corporate decision-makers, they find that the needs that ultimately led to the adoption of an SCF solution differ significantly among the companies, ranging from the need to reduce the financial risk of suppliers and optimize the company's own net working capital, to the need to reduce inventories in the distribution network, etc. They divide these needs into two broad objectives: to improve the adopter's financial performance (OBJ1) and to secure the upstream/downstream supply chain's financial performance (OBJ2). While these objectives represent two extremes,

[7] Innovations in SCF such as reverse factoring and dynamic discounting represent a cost of capital (or credit) arbitrage, in that they exploit the differences in access to and cost of capital of different supply chain participants. Klapper (2006) discusses how factoring may allow high-risk suppliers to transfer their credit risk to higher quality buyers, and how "reverse factoring" may mitigate the problem of borrowers' informational opacity if only receivables from high-quality buyers are factored. See Rogers et al. (2016) for illustrations of SCF programs and Tunca and Zhu (2017) for an exposition of buyer intermediated supplier finance. Although such methods can be used to finance longer-term investments, they are typically used for financing working capital investments.

some companies have both objectives in mind (i.e., they fall somewhere in the continuum).

The second main finding of Caniato et al. (2016) concerns moderating variables that affect the adoption and objectives of SCF solutions. Several findings emerged. First, trade process digitalization enables the adoption of innovative and supply chain collaborative solutions, by providing significant cost savings (relative to a paper-based trade process) and allowing the provision of value-added services. Companies having a high (low) level of trade process digitalization are more likely to have OBJ2-driven (OBJ1-driven) applications. Second, the bargaining power between the companies and the financial attractiveness of the SCF solution affects the adoption and objectives of SCF solutions: a company with more bargaining power vis-a-vis supply chain players is more likely to adopt OBJ1-driven solutions, whereas greater financial attractiveness enables the adoption of OBJ2-driven solutions. Lastly, collaboration also affects the adoption of SCF solutions: intrafirm collaboration (interfirm collaboration) is positively associated with the successful adoption of OBJ2-driven (OBJ1-driven) solutions.

Intra- and interfirm coordination and collaboration among entities in the supply chain raise interesting questions and research opportunities for SCF. Tunca and Zhu (2017) analyze the role and efficiency of buyer intermediation in supplier financing (i.e., when the buyer underwrites a third-party loan to the supplier). Building a game-theoretical model, they show that buyer-intermediated financing can significantly improve channel performance and can simultaneously benefit both the buyer and the supplier. Using data from a large Chinese online retailer, they report that buyer intermediation lowers interest rates and wholesale prices, increases order fill rates, and increases supplier borrowing. Their counterfactual analysis predicts that the implementation of buyer-intermediated financing will improve channel profits by 13.05%, increasing supplier and retailer profits by more than 10% each, and yielding approximately $44 million savings for the retailer. Their theory and evidence suggests that this innovative approach to ease suppliers' budget constraints can not only improve supply chain efficiency, but also may help many small suppliers gain and grow their business, eventually contributing to economic development, trade growth, and value generation around the globe.

Given the clear benefits that SCF can offer, it is important to understand what factors promote or hinder the adoption of SCF solutions. Wuttke, Blome, Heese, and Protopappa-Sieke (2016) document evidence of some hesitation and resistance to SCF adoption, manifested in an often substantial time lag between a buyer's introduction of SCF and its adoption by all targeted suppliers. They find that initial payment terms and procurement volume strongly affect the optimal timing of SCF introduction and optimal payment term extensions, and that the degree to which the buyer can influence suppliers in their adoption decisions affects the optimal introduction timing, but not optimal payment terms. More studies are warranted to examine the efficacy of different SCF solutions and the conditions under which different types of finance (bank vs buyer vs supplier finance) are adopted. Kouvelis and Zhao (2017) and Deng, Gu, Cai, and Li (2018) provide a more recent analysis of these issues.

2.3 AVENUES FOR FUTURE RESEARCH IN SUPPLY CHAIN FINANCE

In concluding their literature review of SCF, Gelsomino et al. (2016) point out four main gaps in the literature: (1) No general theory of SCF, in part due to SCF being a relatively new and complex concept, and in part due to the division of the research into incoherent perspectives. (2) Weak empirical and holistic analyses on the application of SCF (few studies have tested hypotheses and models developed for SCF). (3) Few assessment models to consider the impact of SCF programs on the financial performance of the entire supply chain. (4) Lack of tools for choosing SCF solutions. The last three gaps, as discussed by the authors, pertain more to SCF schemes and solutions of a working capital management nature. While valuable from a practical viewpoint, these gaps risk losing the big picture: SCF is much more than working capital management. If viewed from a more holistic and comprehensive perspective, SCF research can contribute to both academic disciplines and practice (this is in response to the first gap identified). I now turn to what I consider to be gaps in the SCF literature and avenues for future research.

2.3.1 Supply Chain Investment

As mentioned, efficient investment in long-lived assets and capabilities is a major source of value creation, viewed from both a single company's perspective and the entire supply chain. In terms of investment appraisal techniques, the NPV method and the risk-expected return relation (epitomized in the capital asset pricing model) are advocated as two basic principles in finance. Survey evidence from the field (Graham & Harvey,

2001) indicates that large firms rely heavily on present value techniques and the capital asset pricing model, while small firms are relatively more likely to use the payback criterion. In addition, a surprising number of firms use firm risk (WACC) rather than project risk in evaluating new investments. Use of an inappropriate investment appraisal technique and a required return not linked to the project-specific risk are likely to lead to inefficient investments (e.g., Krüger et al., 2015). In the context of supply chain investments, investment appraisal (estimation of the amount and risk of the cash flows) is complicated by externalities created by interfirm linkages along the supply chain (Hertzel, Li, Officer, & Rodgers, 2008), which often extend beyond Tier One suppliers, and by the presence of real options that are often embedded in operational flexibility (Nembhard, Shi, & Aktan, 2005).

Contemporary supply chains are characterized by their complex global connections, diverse stakeholders, and interfirm coordination/collaboration. Against this backdrop, some important questions may be posed. What is an optimal way of making supply chain investments, sharing the risks, and collaborating for mutual benefits? What are the enablers and limiting factors in intra- and interfirm coordination/collaboration? In regard to supply chain investments that span multiple entities, unless the amount of the cash flows and the associated risks can be clearly delineated (incomplete contracts and unexpected circumstances can make this difficult), the rights and obligations of the different entities along the supply chain may not be all that clear, either ex ante or ex post. The result can be an underinvestment in certain assets and capabilities, unless there are other effective ways to overcome the coordination and contracting problem. One way to mitigate such a problem is to enhance visibility/transparency (Christopher & Lee, 2004) and to build trust. How trust is built and maintained, and what are the role and performance impacts of trust in the context of global supply chains?[8] How should management (including accounting) information systems (MIS) be configured to enhance visibility in the supply chain and facilitate intra- and inter-organization communication with a view to aiding efficient investment decisions?

[8] Brinkhoff, Özer, and Sargut (2015) find that trust is necessary but not sufficient for inter-organizational supply chain project success.

In view of the foregoing discussions, a fruitful program for future research may study the following issues:

- The investment appraisal techniques used by supply chain companies[9]
- The cost of capital (required return) models used by supply chain companies
- Optimal ownership and governance arrangements for assets shared by multiple supply chain participants, and the organization and governance of contractual relationships in the supply chain
- The roles and effects of trust and information sharing in collaborative investments and relationships involving multiple supply chain participants.[10]

Researchers investigating these important issues may draw on the large economics, finance, management, and management science literature, which provides a rich set of frameworks, theories, and testing methodologies. For instance, the transaction cost economics (TCE) approach can be used to examine the governance of contractual relations (e.g., outsourcing) in the supply chain (Williamson, 2008), as well as corporate finance applications (Williamson, 1988). The large literature on the roles and effects of trust in collaborative relationships also provides a complementary perspective.[11]

2.3.2 Financing of Supply Chain Investment

Companies have a number of methods for financing supply chain investments, including venture capital, private equity or debt (bank loan), public offering (debt or equity), leasing, and buyer/supplier finance.[12] Depending on the time duration and frequency, one may distinguish between long-term fixed asset investments and short-term working capital

[9] The term "supply chain companies" is used here (and elsewhere) as shorthand for companies along the supply chain. Unlike logistics or transport companies who are stand-alone entities, there are no stand-alone "supply chain companies" (as opposed to supply chain management companies). Each company is a citizen of its supply chain in a web of suppliers, logistics companies, brokers (intermediaries), port operators, and many others (Sheffi & Rice 2005).

[10] Chen (2003) reviews the literature on information sharing and supply chain coordination.

[11] See Lui, Wong, and Liu (2009) for an empirical analysis of the relative descriptiveness of TCE and relational exchange theory (as well as the moderating role of institutional/cultural factors) regarding the link between asset specificity and partnership performance in cooperative procurement relationships.

[12] Basu Bal et al. (2018) suggest that logistics service providers may also act as providers of SCF services because of the informational advantage they have over traditional SCF providers such as banks and various FinTech firms.

investments. Given the global nature and complex interfirm connections in contemporary supply chains, supply chain financing calls for innovations. These may include both technology solutions and new financing arrangements, both long-term and short-term.

A number of case studies have examined how specific (typically large) companies manage their supply chain financing. Blackman, Holland, and Westcott (2013) analyze Motorola's global financial supply chain strategy. They document significant improvements in the company's financial supply chain performance when Motorola aligned the manufacturing and financial supply chains and adopted innovations in the financial processes (including use of a global information system and shared information systems and processes with supply chain partners). Borade and Bansod (2010) and More and Basu (2013) examine short-term financing practices (e.g., vendor management inventory) among Indian firms. Wuttke, Blome, Foerstl, and Henke (2013) discuss how European companies adopt innovative solutions to manage their SCF. As Gelsomino et al. (2016) point out, while these case studies shed some light on innovative practices in supply chain financial management, they fall short of providing a comprehensive framework for classifying SCF solutions and a holistic view of the adoption level of different SCF solutions as well as the associated issues and enablers. They call for future research to address innovative schemes and solutions across the whole spectrum of the supply chain (both the upstream and the downstream).

Most of the existing studies on the financing solutions/innovations in the supply chain focus on working capital management, notably, inventory management, trade credit, and factoring. Future research should also examine innovations in long-term financing, including the buy-versus-lease choice and buyer-versus-supplier finance, with particular emphasis on the implications of shared ownership and relationship-specific assets that characterize the modern supply chain.[13] Given that investments in major assets and capabilities carry a big price tag and contribute to firms'

[13] Strieborny and Kukenova (2016) examine the role of bank finance in investment in relationship-specific assets. A supplier is reluctant to undertake relationship-specific investment as she cannot observe the financial stability and planning horizon of the buyer. Banks can mitigate this information asymmetry and thus potentially overcome the reluctance to invest. Their empirical results from 28 industries in 90 countries confirm that industries dependent on relationship-specific investment from their suppliers grow disproportionately faster in countries with a well-developed banking sector. The channel works via increased entry of new firms and higher capital accumulation.

long-term competitiveness and sustainability, efficient long-term financing for the supply chain (as opposed to working capital management, the focus of much existing research) deserves much more research attention.

2.3.3 Accounting/Financial Information and Disclosure in Supply Chains

Accurate, reliable, and timely information is crucial for making efficient investment and financing decisions. For example, the NPV technique requires accurate estimates of *incremental* cash inflows and cash outflows (Ross et al., 2016). Complex supply chains and the associated uncertainties present a major challenge for coming up with accurate cash flow estimates and for risk management.[14] In order to determine the incremental changes in cash flows that result from investing in a given asset/capability (e.g., a new regional distribution center), the decision-maker must ascertain the costs and revenues with and without the new investment. Thus, to a large extent the quality of the company's MIS (including accounting) determines the efficiency of the investment and financing decisions. Can the traditional management accounting system accurately identify and quantify the value drivers and cost drivers for different products/services within a firm and, more importantly, for products/services that cut across multiple entities in the supply chain? What kinds of accounting systems do supply chain companies currently use, and how do different accounting system configurations impact firms' operating and financial performance? At present, there is very limited research on supply chain companies' management accounting practices, information needs/availability/quality, and their impact on inter-organizational collaboration and performance.[15]

[14] Information risk is often classified as a major category/source of supply chain risks (e.g., Tang, 2006; Tang & Musa, 2011); however, this risk category has received relatively limited attention in the supply chain literature (Ho et al., 2015).

[15] Frances and Garnsey (1996) discuss the role of information technology and accounting information in facilitating organizational integration and control in the context of UK supermarkets. Free (2008) presents a case study of how information exchange and supply chain accounting were used to initially build trust and collaboration among UK supermarkets and suppliers, and how such practices subsequently resulted in distrust and cynicism. In a slightly different vein, Cen, Maydew, Zhang, and Zuo (2017) investigate whether firms in close customer—supplier relationships are better able to identify and implement tax avoidance strategies via supply chains. They find that both principal customer firms and dependent supplier firms have lower Generally accepted accounting principles (GAAP) and cash effective tax rates than otherwise similar firms, consistent with close customer—supplier relationships facilitating tax avoidance. Moreover, customer—supplier tax avoidance helps explain firms' organizational decisions, for both principal customers and dependent suppliers.

While information within the focal firm is crucial for internal decision-making, information/disclosure about other entities in the supply chain, both upstream and downstream, is also of increasing importance. This is not only because such information is needed for price/contract negotiations with external parties, but also because there are mounting concerns for environmental, social, and governance (ESG) investing, sometimes under the auspices of stock exchange requirements and laws (e.g., the Dodd-Frank Act in the United States). Against this backdrop, corporate obligations now go beyond their own operations and companies are held accountable for the actions of their suppliers with regard to their supply chains (Islam & Van Staden, 2017). Failure to demonstrate accountability and transparency in the supply chain thus may expose companies to reputational sanctions and/or regulatory actions. In recognition of such concerns, some companies have issued corporate social responsibility (CSR) or sustainability reports to allay stakeholders' pressure to incorporate social, environmental, and economic responsibility considerations into operations and SCM strategies (Tate, Ellram, & Kirchoff, 2010). However, disclosure and environmental sustainability reporting of the supply chain is hindered by the multiplicity of competing reporting standards and organizations, the significant difficulties, costs and time commitment required for collecting information on the entire supply chain, and limited benefits associated with such reporting (Bateman, Blanco, & Sheffi, 2017).

Future research may address the following issues:

- Requirements for high-quality supply chain information: What are the information needs of supply chain companies? What challenges are companies facing in terms of accurately determining their cost and value drivers across the entire supply chain? Are there cross-country and interfirm differences in the availability and quality of information pertaining to the supply chain, and, if so, what are the key determinants and the performance impacts?
- MIS and costing in the supply chain: What are the state-of-the-art practices in supply chain accounting? What are the enablers, issues, and performance impacts of implementing activity-based costing and total costing in the supply chain? How does information sharing (in the form of open book accounting, joint performance management, and joint forecasting, etc.) among supply chain partners impact supply chain collaboration and performance?

- Corporate voluntary disclosure: What is the extent of CSR and ESG reporting for the supply chain? What are the characteristics of companies that engage in voluntary disclosures pertaining to their supply chains? What are the consequences of voluntary disclosure of supply chain information, for example, with respect to the cost of capital, product/service uptake, brand equity, and collaboration with other organizations?

Research along these lines may be guided by a large accounting and finance literature on the antecedents and consequences of corporate disclosure (e.g., Armstrong, Guay, & Weber, 2010; Beyer, Cohen, Lys, & Walther, 2010; Bushman & Smith, 2001).

2.4 SUPPLY CHAIN RISK MANAGEMENT

The SCRM literature is much larger than the SCF literature, probably because the former has attracted far more researchers from nonbusiness fields such as operations research/management. There are a considerable number of review articles and books dedicated to SCRM, including supply chain risk definition, categories, causes, assessment methods, and mitigation/response strategies. In this chapter, I focus on summarizing the main findings and conclusions from existing studies (books are excluded), before moving on to present my own view of the gaps in the literature and avenues for future research.

2.4.1 Existing Research on Supply Chain Risk Management

In a relatively early review paper, Jüttner et al. (2003) define the concept of SCRM based on four basic constructs: supply chain risk sources, risk consequences, risk drivers, and risk mitigating strategies. Besides synthesizing the literature on the basis of these constructs, they also conducted exploratory interviews with supply chain practitioners to discover their perceptions of supply chain risk and current SCRM strategies.

Manuj and Mentzer (2008a) bring together the concepts, frameworks, and insights from multiple disciplines and propose a comprehensive risk management and mitigation model for the entire supply chain (as opposed to a single firm). They provide a step-by-step procedure to identify, assess, and manage risks. They note that to implement such a procedure, it is necessary to not only develop tools and techniques to assign probabilities to events, but also understand the key enablers in the process of risk management and mitigation (e.g., organizational learning, information systems, and performance metrics/rewards). They call for future interdisciplinary research to empirically validate their model and investigate the causal effects of risk management on performance (as well as the moderating and mediating variables). Manuj and Mentzer (2008b) respond to this call by conducting 14 in-depth interviews of senior supply chain executives across eight manufacturing companies. On the basis of these interviews, they develop a refined definition of supply chain risk and four types of global supply chain risks.[16] They also identify several antecedents that led to the adoption of global SCRM strategies and moderators of risk management outcomes. Although Manuj and Mentzer (2008b) represent a valuable theory-building attempt based on a systematic literature review and empirical data (interviews), it leaves open the possibility that different people/organizations have different opinions and practices with regard to the definition, assessment, and mitigation of global supply chain risks.

Sodhi et al. (2012) review the research literature on SCRM and present survey results from both practitioners and academic researchers. They identify three gaps: a definition gap in how researchers define SCRM, a process gap in terms of inadequate coverage of response to risk incidents, and a shortage of empirical research in the area of SCRM. To close such gaps, the survey respondents suggest that there is a need for more involvement with industry for case-study- and event-study-based research, as well as the need for more conceptual work on which to base the empirical research. Sodhi et al. (2012) also call for a study of practitioner communities to determine the particular risks in their respective companies, the type of data they can provide regarding risk events, and what type of collaborations they want to have with academic researchers.

Ho et al. (2015) review and synthesize the more recent (2003—13) literature in SCRM and propose a new definition for SCRM by classifying supply chain risk types, risk factors, and risk management methods. They identify several future research directions, including more research on infrastructural risks such as transportation, information, and financial risk; the use of primary data to investigate the applicability and effectiveness of theoretical SCRM models in practical situations; and testing the adaptability and flexibility of the SCRM models by applying them to different

[16] Risk in a global supply chain text is defined as the distribution of performance outcomes of interest expressed in terms of losses, probability, speed of event, speed of losses, the time for detection of the events, and frequency (p. 197). Such a definition does not adequately reflect the global dimension of supply chains.

companies in the same or different sectors, both within and across countries.[17]

2.4.2 Research Agenda for Supply Chain Risk Management

As the preceding literature review indicates, much has been written about the definition, sources, consequences, and assessment methods for SCRM. Therefore, I focus on risk management techniques in discussing avenues for future research, with an emphasis on financial aspects of risk management for the supply chain, as there are already a large number of SCRM studies from an operations management perspective. I take for granted the (albeit not universally accepted) definitions, sources, consequences, and assessment frameworks of supply chain risks. I do not concern myself with strategic, operational, or organizational decisions that deal with supply chain risks, though these and financial risk management are interrelated.[18],[19]

Recent studies such as Cunat (2007), Costello (2013), and Gamba and Triantis (2014) suggest that there is potential to expand the scope of SCRM to include not only operational decisions, but also investment, financing, and governance issues (including corporate disclosure and contractual relations) in the supply chain. The existence of a large theoretical literature and well-established methodologies in these fields can provide both the theories and empirical methods to guide future research in SCRM.

[17] See Sheffi (2018) for more discussions of risk modeling in supply chains.

[18] By way of illustration, a strategic decision may involve a company choosing to deal with multiple suppliers rather than a single supplier. Such a decision lowers the chance of suffering a major disruption to supplies caused by unexpected problems with the single supplier, but has obvious offsetting disadvantages. An operational decision may involve making supply chains "lean" and achieving just-in-time delivery, but risk creating vulnerability when a when a brittle supply chain snaps. Finally, as an example of organizational decisions, the CEO may completely delegate supply chain risk management to a risk manager or supply chain manager.

[19] Ding, Dong, and Kouvelis (2007) study the integration of operational and financial hedging by considering an international firm that faces domestic and foreign demand risks as well as currency exchange risk. They show that the firm's financial hedging strategy ties closely to, and can have both quantitative and qualitative impact on, the firm's operational strategy. The use, or lack of use of financial hedges, can go beyond affecting the magnitude of capacity levels by altering global supply chain structural choices, such as the desired location and number of production facilities to be employed to meet global demand.

An issue for which more research is warranted concerns the theory and practice of investment in shared assets/capabilities in the supply chain and associated risk sharing arrangements. As de Zegher, Iancu, and Lee (2017) point out, in complex supply chains the benefits and costs of technological innovations do not always accrue equitably to all parties and, thus, their adoption may critically depend on sourcing relationships and incentives. There is a need to study ways to create mutual benefit in decentralized value chains, where suppliers bear the costs of new technologies while benefits accrue primarily to buyers. While de Zegher et al. (2017) focus on contract design and sourcing channels, future studies may analyze optimal financing and risk sharing arrangements that encourage investments that create shared value.

In a paper related to the aforementioned issues, Almeida, Hankins, and Williams (2017) analyze purchase obligations (POs), or contractual obligations between a downstream firm and an upstream firm, as a (financial) risk management tool. They show that POs with suppliers are a corporate hedging tool, just like traded derivatives, that downstream companies commonly use to manage price fluctuations and hold-up problems between suppliers and customers.[20] Using 10-K fillings of US publicly listed firms during 2003–10, they document that the introduction of traded derivatives reduced firms' demand for POs and that collateral value, financial distress, and the costs of using POs (settlement risk and supplier bargaining power) are moderating factors in the substitution between POs and traded derivatives. Given the ready availability of data about POs (or other types of risk-related data) and customer–supply relationships among publicly listed firms (Cen et al., 2017; Ellis, Fee, & Thomas, 2012; Fee & Thomas, 2004), there is scope for more empirical studies on the antecedents and consequences of supply chain risk (or, for that matter, financial) management practices both across multiple industries, and across countries, in response to calls for more (especially empirical) research in SCRM (Ho et al., 2015).

[20] As Almeida et al. (2017) argue, doing so expands the definition of hedging and constitutes a key contribution to the literature. Their paper also exemplifies that supply chain finance and risk management are interrelated.

2.5 AN INTEGRATED AND MULTIDISCIPLINARY APPROACH TO SUPPLY CHAIN FINANCE AND RISK MANAGEMENT

The comprehensive review of the SCF and SCRM literatures reveals that both topics are multidisciplinary in nature, having attracted researchers from diverse fields ranging from operations management, transportation, logistics, accounting, finance, and economics. This should come as no surprise, given that the contemporary supply chain involves multiple processes and functional departments (Chopra & Meindl, 2016), both within a firm and across entities in the entire supply chain. The increasingly interconnected (and typically global) nature of supply chains requires a holistic and multidisciplinary approach to managing the supply chain. A silo ("single-discipline") mentality or fragmented approach to supply chain research and practice can at best provide an incomplete picture of key drivers of superior supply chain performance and of critical issues in SCF and risk management.[21] In the same way that effective SCM requires intra- and inter-organizational collaboration, informative and insightful supply chain research calls for collaboration among researchers from multiple disciplines.

2.6 SUMMARY AND CONCLUSIONS

The chapter presents a selective review of the literature in SCRM and SCF (broadly defined). Both topic areas are characterized by a large diversity, in terms of definitions of key concepts, scope of investigation, and research methods. Such diversity reflects the emerging nature of these research areas (in particular SCF), the fast changing landscape of industry practice, and the vastly different academic backgrounds of the researchers. The literature review leads to the identification of a number of significant knowledge gaps and suggested avenues for future research. It is hoped that an integrated and multidisciplinary approach to SCF and risk management research will enrich our knowledge of these important topics.

[21] Industry practitioners are well aware of the interactions between operational decisions and financial risk in the supply chain and call for Chief Financial Officers to drill more deeply into their organizations to know about supply chain risks, such as the resilience of key suppliers (see Burchill, 2015).

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CHAPTER 3

Different Perspectives on Supply Chain Finance—In Search of a Holistic Approach

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3.1 INTRODUCTION

Since the 1980s, capital rationalization has been at the heart of logistics education and industry practice. The intensity has changed over time and motives include high interest rates, lack of working capital, focus on financial key performance indicators, shorter product life cycles, and a continuous cost pressure. Nevertheless, there has been a gap between the changes of the physical flow and the financial flow. Often the logistics manager allocates much effort and costs to shorten lead times by hours, just to learn that large customers force the sales manager to accept credit extensions in the range of months. Globalization and fragmentation of supply chains have also contributed to an increased interest in financial flows between firms.

The literature on supply chain finance (SCF) is much more recent than that on capital rationalization, but it has grown exponentially over the past decade (see Gelsomino, Mangiaracina, Perego, & Tumino, 2016, for a recent review). Important themes include how to define SCF, how to distinguish SCF from other similar terms, the pros and cons of SCF for different actors, and the various techniques used to apply SCF. The present chapter aims to summarize these key themes under a conceptual model proposed by Liebl, Hartmann, and Feisel (2016). The model is useful because it allows for a broad and holistic discussion of SCF, and we extend the model by elaborating on the logistical, financial, and legal aspects related to the key themes.

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Section 3.2 presents the model and then Sections 3.3–3.5 are used to discuss SCF from the perspectives of logistics services, finance, and law. Then Section 3.6 focuses on how critical links and working capital in such chains are affected by the requirements of greater visibility and reduction of existing information asymmetry, after which conclusions are drawn.

3.2 DEFINITIONS AND CONCEPTUAL MODEL

Gelsomino et al. (2016) divide the SCF literature into two major perspectives: (1) the finance oriented perspective and (2) the supply chain oriented perspective. The former tends to define SCF more narrowly as a set of short-term financial solutions, primarily related to payables and receivables. From this perspective, financial institutions are important to the analysis in which their role in designing new solutions to facilitate trade-related financial flows is stressed. Because these solutions normally stem from reverse factoring (RF), or an evolved form of RF, there is a stream of literature within this perspective that deals with the buyer-driven nature of SCF. The supply chain oriented perspective, on the other hand, has a broader scope focusing more generally on capital optimization throughout the entire supply chain. This latter perspective tends to depart from traditional supply chain analysis; arguing that while research has come far in the analysis of integrated management of physical and informational flow along the supply chain, it largely ignores the financial flows (cf., Gomm, 2010; Pfohl & Gomm, 2009).

Routed in the supply chain oriented perspective, Liebl et al. (2016) propose that SCF is ordered under the broader term financial supply chain management (FSCM) in accordance with Fig. 3.1. Following Wuttke, Blome, and Henke (2013), Liebl et al. (2016, p. 395) define

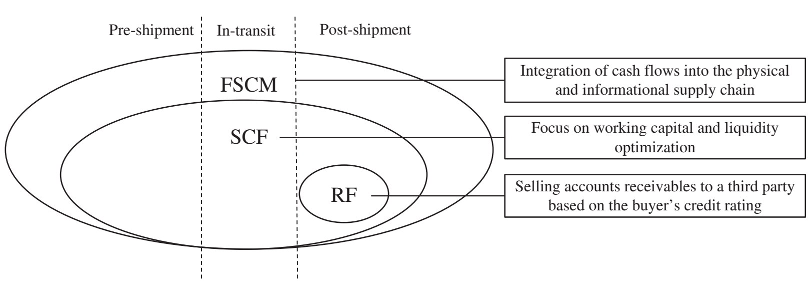

Figure 3.1 Overview of FSCM research streams. *Based on Liebl et al. (2016), p. 395.*

FSCM as the "[...] optimized planning, managing, and controlling of supply chain cash flows to facilitate efficient supply chain material flows." The definition allows for the use of FSCM as an umbrella term encompassing the three distinct flows (physical, informational, and financial) for efficient supply chain management. This means that SCF, as part of FSCM, devotes specific focus toward the financial flow, in general, and working capital and liquidity optimization, in particular. In their conceptualization, it is also within SCF that the financial service provider enters. They define SCF "as an approach for two or more organizations in a supply chain, including external service providers, to jointly create value through means of planning, steering, and controlling the flow of financial resources on an inter-organizational level" (Liebl et al., 2016, p. 396). Thus, it is useful to think of their model in terms of FSCM being closer to the supply chain oriented perspective and SCF as being closer to the finance oriented perspective.

An area where this distinction between SCF and FSCM is perhaps less clear-cut relates to the role of logistics service providers (LSPs). Several studies have pointed to the prominence of LSPs as providers of SCF services (cf., Basu Bal, Elliot, Lindblom, Rajput, & Woxenius, 2017; Hofmann, 2009), because of the informational advantage that LSPs have over traditional SCF providers (such as banks and various FinTech firms). Still, LSPs are experts in traditional logistics and SCM services, while less experienced in providing financial solutions. This means that we can think of two different approaches for LSPs to enter into the finance realm that helps in clarifying the difference between FSCM and SCF. If the LSP decides to adopt the FSCM approach, it would offer its customer integrated solutions that encompass the management of all three flows simultaneously. This approach would focus on the trade-offs between efficiency in, for example, the physical and financial dimension. If a buyer would like to extend the payment terms to their suppliers, it is done in a manner that does not risk the financial well-being of their suppliers and hence damages the supply chain (e.g., through increased disruption risk). If the LSP would instead adopt the SCF approach, it would have a separate department dedicated to identifying finance-related inefficiencies across the supply chain. This latter approach would leave it to the focal firm to decide whether the financial solution proposed imposes restrictions on the physical or informational flows.

The third level in the Liebl et al. (2016) model focuses on RF, which is perhaps the most commonly used and well-developed "post-shipment" financial arrangement within the frame of SCF. RF is a method commonly initiated by the buyer to extend payment terms. In an RF scheme, the factor allows suppliers to borrow based on the credit rating of the buyer. Traditionally banks have played the role of factor, but there is growing competition from various FinTech firms that provide third-party platform solutions based on either one-bank financing or multibank financing.

In a simplified version of this method, the original payment terms were 30 days. Applying a RF scheme, the buyer can extend the payment terms (e.g., to 60 days) while simultaneously allowing the supplier to access their payment from the factor earlier (e.g., within 10 days) at a predetermined interest rate. As long as the supplier's credit rating is worse than the credit rating of the buyer, there is potential for credit arbitrage. However, even without credit arbitrage, the supplier's liquidity risk and, hence, the supply chain disruption risk, are reduced if the extension of the payment terms is a buyer prerequisite for future trade (cf., Elliot & Lindblom, 2017; Klapper, 2006; Lekkakos & Serrano, 2016).

Liebl et al. (2016) separate the different SCF solutions into two phases: pre-shipment financing and post-shipment financing. With reference to the related work by More and Basu (2013), we add the "in-transit" phase. This is because FSCM is focusing on the entire supply chain, where most pre-shipment and all in-transit solutions are included. To exemplify, think of a supply chain with three tiers of suppliers and one buyer. If the Tier 2 supplier benefits from pre-shipment solutions, such as equipment or raw material financing, it may in fact be pre-shipment for the Tier 1 supplier and post-shipment for the Tier 3 supplier. This illustrates that the categorization of SCF solutions is highly dependent on whether a complete supply chain perspective or just a dyad is adopted (Andersson, Dubois, Holma, & Hulthén, 2014).

The above holds true for SCF in general but not necessarily for RF. RF has been predominantly used in a dyadic relationship between a buyer and a supplier. Nevertheless, in recent times there is evidence that large buyers extend RF schemes to encompass Tier 2 or even Tier 3 suppliers where a wide variety exists for access to, and cost of, capital. This could potentially move RF into an earlier phase of the supply chain. In addition, the emergence of platforms extends the reach of RF. For example, the National Commodities and Derivative Exchange Ltd. (NCDEX), a commodity bourse for trading agricultural commodities in India, has established a commodity exchange platform through its subsidiary

Table 3.1 SCF solutions in different supply chain phases

Supply chain phase / SCF solution	Pre-shipment	In-transit	Post-shipment
Equipment financing	x		
Raw materials financing	x		
Purchase order financing	x		
Pay on production	x		
Vendor leasing	x		
Supplier subsidies	x		
Vendor-managed inventory	x	x	
Consignment stock		x	
Inventory financing		x	
Reverse factoring			x
Dynamic discounting			x
Seller-based invoice auction			x
Captive factoring			x

NCDEX e-Markets Limited (NeML) to finance various stages of the domestic agricultural supply chain. Financing is provided to farmers through e-pledge, to traders through storage in accredited warehouses, and to the processors through receivables bill discounting. RF for NeML marketplace participants is made available in association with a financial technology partner Indifi.

A selection of different SCF solutions, separated into the three phases, is presented in Table 3.1.

Vendor-managed inventory is marked in two columns since the goods are physically moved to the customer's premises but not legally delivered until the customer takes the product out of the stock. The customer has not ordered the specific product and sees it as pre-shipment, whereas it has left the seller's premises characterizing it as in-transit. The following three sections discuss previous research efforts within SCF from the logistics service, finance and legal perspectives.

3.3 SUPPLY CHAIN FINANCE FROM A LOGISTICS SERVICE PERSPECTIVE

The logistics and freight transport textbooks mainly focus on the management of physical flows, but often contain figures and texts on different types of flows and their relationships. Starting with the physical infrastructure at the bottom, they generally add flows of vehicles and articles. Over time, these figures have been extended with more flow layers with components and markets. One example is to add a layer of consignments between the flow of vehicles and articles, as LSPs design their systems to move consignments, each of which often contains several articles. In more recent models like in Fig. 3.2, the financial flows are also included highlighting the opposite directions of money and articles.

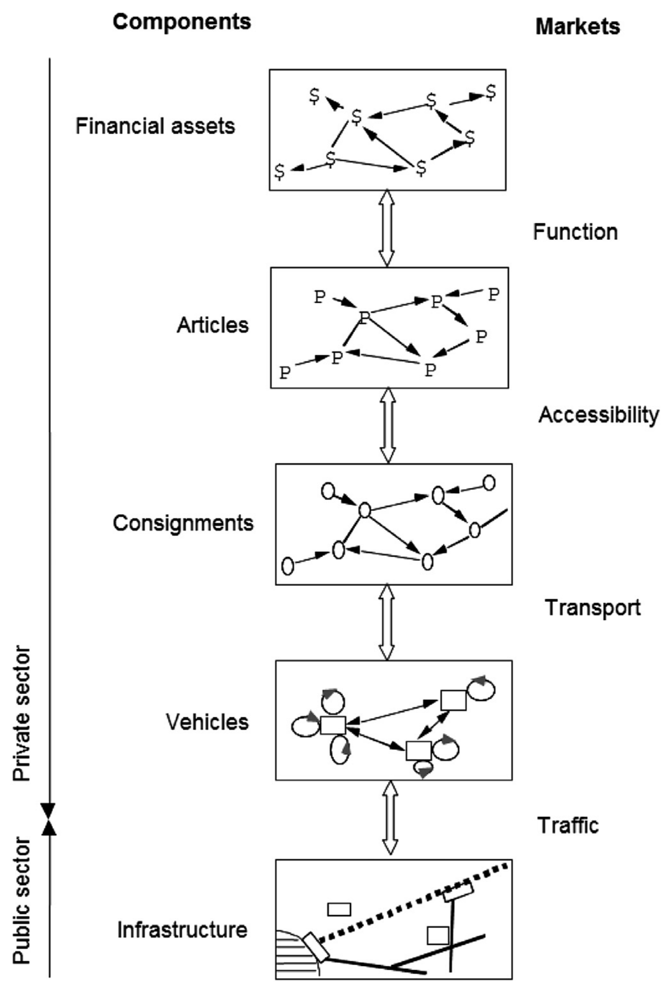

Figure 3.2 Model of the logistics system with associated markets. *Translated and slightly adapted from Lumsden (2012), p. 22.*

Yet other conceptual models add a layer of information flows, but nowadays the need for a well-functioning information exchange is implicitly part of any complex system and not treated separately. Information flows are hence part of each layer.

The most basic service provided by LSPs and their eventual subcontractors is transport that is creating place utility by changing the address of consignments by using vehicles and vessels. Chen and Hu (2011) denote this as "the traditional role." In the role of LSPs as third-party logistics operators (3PLs), they store their clients' articles and process delivery orders. In neither case do they carry the capital cost of the goods. Hence they do not aim at minimizing the time goods spend in their systems but they are subject to the derived demand for short transport time and punctuality. In particular, transport services that include fast transport, mainly air transport and partly road transport, benefit from a high cost of capital tied up in the moved products.

To a large extent, freight transport and basic logistics are commoditized services with very thin profit margins. To access markets with higher yields, LSPs can offer more complex 3PL services like warehousing, predelivery inspection and customization services, or even more ambitious 4PL services setting up control towers managing all goods flows of their clients and selling logistics consulting services. These offerings are sometimes denoted value-added services, meaning an add-on to the basic function of providing place utility. This is in line with the developments in other commoditized markets like automotive, retailing, and travel services that get large shares of profits from add-on services.

While banks have reduced the number of branches, as much of their business is done over the Internet, LSPs maintain a well-distributed physical presence. Hence they monitor the flows of goods and possess information about the place and condition of goods. As such, they might offer information to SCF providers or consider offering SCF services directly to shippers based on their access to information (Basu Bal, Elliot, Lindblom, et al., 2017). As many of the leading European LSPs including DB Schenker, DHL, the large national railways and the "flag carrier" airlines are still fully or partly state-owned and they can, at least in theory, access capital at very low cost. It is yet uncommon that logistics firms offer financial value-added services, particularly in the road freight transport market dominated by numerous small hauliers. Nevertheless, according to Chen (2016), logistics financial services are the first profit source for very large LSPs like Maersk and UPS.

Since most manufacturing and trading firms outsource logistics and freight transport activities, conceptual models of supply chains often include LSPs at each interface between product sellers and buyers. Yet, LSPs are just vaguely integrated into supply chains that ship small items in multiuser consolidation networks, whereas the relationship is very intimate in long-term full-load transport, 3PL, and other contract logistics services. One example is the Chinese shipping line COSCO's contract with the Brazilian ore company Vale to move 16 million annual tons of iron ore from Brazil to China for 27 years (COSCO, 2016). The long duration of the contract reflects the long life span of dry bulk ships and allows COSCO to invest in a fleet dedicated to serve Vale. This contract alone corresponds to the transport work performed by all road freight transport in EU-28 for 5 years and, of course, COSCO is very closely integrated into the supply chains of Vale and its customers. In another example, taken from the data collection for Basu Bal, Elliot, Lindblom, et al. (2017), a large LSP through their 4PL department take over ownership of in-transit goods and store it in a warehouse until it is requested by the buyer. During this process they rely on their financial strength to finance the goods for which they are paid a fee. While the LSP expressed that this is currently not a common setup, more customers are starting to request it and they are discussing whether to expand further in this area.

In an SCF context, the importance of LSPs in supply chains also varies considerably depending on the transport time. For short and medium distance hauls by road, transport is often overnight, and a similar transport time applies for air transport. Full load system trains are also fast, but wagon loads over long distances involving several countries can last a week and a train between China and Western Europe about 2 weeks. Nevertheless, it is maritime transport between continents that tie up the majority of the capital in-transit. For most other logistics services, SCF is mainly an issue of covering capital tied up in storage or during the credit time.

It is interesting to compare airfreight and container shipping, both serving intercontinental trade. A Boeing 747 airfreighter costs about USD 250 million with a payload of about 160 tons compared to the newest generation of large containerships with a price tag of about USD 160 million with a deadweight tonnage of almost 200,000 tons. Although the goods value density is much higher for airfreight, it is fair to say that air transport mainly ties up capital in the transport equipment and maritime transport in the goods carried. Considering also the voyage time of 6–8 weeks between East Asia and Northern Europe compared to about 10 hours of flight time, it is evident that maritime transport ties up the majority of in-transit capital in international trade.

An example of the amount of capital tied up in-transit is that Maersk Line in 2006 claimed that "At any one point in time, Maersk Line is transporting cargo worth approximately three percent of the world's GNP." With a GNP of USD 36 trillion in 2005, this corresponds to more than USD 1 trillion tied up at Maersk's ships. Between 2006 and 2016, containerized trade grew by 60% from 115 to 185 million twenty foot equivalent units (TEUs) (UNCTAD, 2016) and Maersk's flows grew by 70% from 12.2 MTEU in 2006 (A.P. Møller—Mærsk A/S, 2007) to 20.2 MTEU in 2017 (A.P. Møller—Mærsk A/S, 2017). In 2017, the capacity of Maersk Line's fleet was 3.3 MTEUs, making up one-sixth of the world fleet of 20.3 MTEUs (A.P. Møller—Mærsk A/S, 2017) indicating that capital tied up in products onboard container vessels is in the range of USD 10 trillion in 2017. It seems to be a rather high estimate with an average cargo value of some 50 USD/kg assuming fully loaded ships and an average cargo weight of 10 tons/TEU. Nevertheless, it gives some perspective on the vast magnitude of SCF needed for propelling world trade.

There is a legal aspect strengthening the position of LSPs in supply chains. In the case of a shippers' insolvency, LSPs can withhold goods until they have received payment for the transport service. In addition, they are often less dependent on the product buyer compared to product suppliers, as they can sell their commoditized transport services to other customers while suppliers have often invested in developing the relationship, joint product development, and in specific machinery for serving the customer. Hence, LSPs are often more prone to request bankruptcy or halt the deliveries when they are not paid. One example is DB Schenker, the leading LSP in the Swedish market, which refused to deliver components to SAAB Automobile when the latter failed to pay for transport services (Johansson, 2011), eventually leading to SAAB Automobile's bankruptcy.

3.4 SUPPLY CHAIN FINANCE FROM A FINANCE PERSPECTIVE

Analysis of SCF from a financial perspective has its origin in the broader literature on trade credit and trade finance. As noted by Auboin (2007, p. 1) finance is fundamental to the function of trade and "[...] an efficient financial system is one indispensable infrastructure to allow trade to happen." International trade transactions generally include two types of financing between importers and exporters, namely, inter-firm trade credit and intermediated trade finance. In inter-firm trade credit, funds in terms of payments are transferred directly between two trading firms either after ("open account") or before delivery ("cash in advance"). Intermediated trade finance involves a third party, i.e., a financial intermediary which is often a bank offering a "letter of credit" to facilitate their trading by reducing information asymmetry (see Ahn, 2011, for an extended discussion.)

Schmidt-Eisenlohr (2013) provides a formal analysis of firms' choice of payment contracts in international trade finance. Based on his analysis, the allocation of payment-related financial risk exposures differs between importers and exporters under the various financial arrangements and forms of trade finance, i.e., there is a trade-off between risk and expected return. When using open account payments in an inter-firm trade finance arrangement, the exporter takes on an exposure to credit risk in order to export more goods at a premium price. To some extent price premiums are dependent on market conditions, but without compensation for taking on additional risk the exporter will fail to create value. This implies a lower price on goods sold when it is instead the importer who extends a trade credit by paying in advance.

Nevertheless, there are limits to the size of these price premiums, which is particularly evident when prices are adjusted to compensate for uncertainty caused by information asymmetry. Schmidt-Eisenlohr (2013) shows that as prices increase, so does the likelihood of adverse selection, i.e., the exporter ends up attracting only the "riskiest" importers. Hence, at some point it becomes rational to adopt an intermediated trade finance arrangement to bypass information asymmetry. This point is in principle determined by the fees charged by financial intermediaries to offset information asymmetry and the opportunity cost of adverse selection (including contract enforcement costs). Hence, the choice of trade finance contract is dependent on the opportunity cost of adverse selection, which means that if information asymmetry can be reduced so can the fees charged by the intermediaries.

Klapper (2006) offers one of the early contributions on the specific role of SCF as a means to address the information asymmetry problem in trade. She compares RF to traditional factoring arrangements and illustrates the benefits of relying on the credit quality of transparent buyers rather than opaque suppliers for the financing of trade. She also notes the importance of legal and technological barriers for trade facilitation and argues that this is a second benefit of RF since such programs are generally reliant on firms in countries with well-developed legal structures and technologies.

Several studies have followed Klapper (2006) and formalized the arguments through various modeling efforts (cf., Iacono, Reindorp, & Dellaert, 2015; Lekkakos & Serrano, 2016; Tanrisever, Cetinay, Reindorp, & Fransoo, 2015; van der Vliet, Reindorp, & Fransoo, 2015; Wuttke, Blome, Heese, & Protopappa-Sieke, 2016). These models give insights with regard to how the gains from various SCF arrangements are allocated both under deterministic and more sophisticated stochastic conditions. However, the vast majority of these studies only consider dyadic settings between one buyer and one supplier, and therefore the next part of the discussion focuses on the finance-related implications of extending financing across the entire supply chain, rather than just between two players.

Elliot and Lindblom (2017) extend Iacono et al.'s (2015) model by identifying two rather basic ratios that can be utilized to evaluate (1) the conditions under which a supplier finds it beneficial to enter into an RF arrangement and (2) the overall value creation of the RF scheme. The first ratio is based on the idea that if the supplier's current interest rate (r_s) divided by the RF rate (r_{SCF}) is greater than the time period the RF rate is used (R_s) divided by the actual time reduction of the invoice payment ($T_s - T_{s,SCF}$) the supplier gains from the RF arrangement:

$$\frac{r_s}{r_{SCF}} > \frac{R_s}{T_s - T_{s,SCF}} \tag{3.1}$$

Departing from a stylized scenario of perfect information and complete competition, the second ratio identifies the overall value creation (π_{RF}) of the RF scheme by making the rather realistic assumption that the interest rate of the buyer (r_b) is lower than that of the supplier (r_s) such that $r_s = \alpha + r_b$ ($\alpha > 0$):

$$\pi_{RF} = \alpha \times V \times \left(\frac{T_s - T_{s,SCF}}{365} \right) \tag{3.2}$$

V is the monetary invoice value and accordingly the greater the α (i.e., the difference between the buyer's and supplier's interest rates) the greater the value of the RF scheme. Perhaps more interestingly, when information asymmetry is introduced, the buyer's interest rate may still largely mirror the true opportunity cost of financing, while the supplier's interest rate may increase because it is considered less transparent. This would automatically make α increase and, thus, increase the value of the RF scheme. Two additional insights can be gained from this ratio. First, because it is reasonable to expect that information asymmetry is greater further upstream in the supply chain, the potential value of the RF scheme would also be greater if it is extended beyond the Tier 1 supplier. Second, the increase of value creation in the RF scheme may be somewhat time-sensitive as the existing information asymmetry between different supply chain actors will decrease gradually as more of their private information is revealed through their continuous trade.

Finally, an area that has received rather scarce attention from a financial perspective is the role of banks and third-party platform providers in SCF arrangements. The study of Liebl et al. (2016) of the different actors involved in SCF marks a notable exception. Representatives identified as key personnel were interviewed about the objectives, antecedents, and barriers to implementation of RF programs. The bankers shared a similar view relating to the importance of transaction volumes, credit ratings, and the country-specific know-how of banks for RF. The bankers also emphasized legal structures as a potential barrier and the next section will elaborate further on the legal perspective of SCF.

3.5 SUPPLY CHAIN FINANCE FROM A LEGAL PERSPECTIVE

Over the past several years, numerous international and regional institutions have been engaged in law-making initiatives related to e-commerce, paperless trade, electronic single window, and cross-border e-transactions. Most of these initiatives feature under the broad heading of "trade facilitation." Trade facilitation initiatives are commonly considered to create standards and guidelines for the exchange of goods and services across borders. Several institutions have defined trade facilitation and almost all the definitions emphasize the flow of information connected with the physical movement of goods. The World Trade Organization (WTO) defines trade facilitation as the simplification and harmonization of international trade procedures, where trade procedures are the activities, practices, and formalities involved in collecting, presenting, communicating, and processing data and other information required for the movement of goods in international trade. Flow of information, which is one of the key components in the above definition, can be enhanced through digitization of trade processes. It helps businesses and governmental agencies to manage risks and reduce transaction costs (World Bank, 2017). Therefore, SCF fits well within the scheme of trade facilitation, as it essentially relates to managing information flows and creating security interests so that the financial processes of all supply chain actors can be serviced at a higher level. It should be noted that the tax structure, accounting standards, and the regulatory environment of financial institutions of a jurisdiction also have an important effect on SCF but they are left outside the scope of this chapter.

A contract for sale is the starting point of any commercial transaction and it is closely interrelated with other contracts relating to carriage of goods, insurance, and financing. Once the goods are shipped through an LSP, the seller issues an invoice to the buyer and is entitled to payment within a stipulated number of days. The LSP directly, or through its eventual subcontracted transport operators, has knowledge about the location of the goods and may also physically possess the goods. In addition, it often holds valuable insight into the seller's and buyer's business conditions. Over the years LSPs have developed their own practices to track goods in international supply chains, and now they have the possibility to turn this knowledge into an opportunity to develop related financial services.

An alternative approach in the supply chain can be that an LSP is not only responsible for transport, handling, and storage, but also emerges as a financier. For instance, a Swiss LSP buys the goods from the manufacturer and obtains an interim legal ownership before selling them to the manufacturers' customers after a certain time. The LSP is also supported by a purchase guarantee from the manufacturer, which the manufacturer has negotiated in framework agreements with its customers. The rationale of this alternative approach is to achieve an improvement in the inventory financing within the supply chain by adopting a "network perspective." Hofmann (2009) argues that, from a business perspective, it makes sense for the LSP to assume ownership of the goods because they have an informational advantage over the bank, but we submit that there is also a legal reasoning that necessitates transfer of ownership to the LSP. Under Swiss law, creating a security interest in moveable property requires more than a pledge agreement. Since there is no security interest register in which the information about a pledge agreement is publicly available, an enforceable pledge of moveable property requires that the pledgor physically deliver the property to the lender in compliance with the *Faustpfandprinzip* (which literally means the first pledge principle) (Wyss, 2008). A Swiss court will not consider a pledge to be perfected if the transaction structure is an obvious attempt to circumvent the *Faustpfandprinzip*. Therefore, the transfer of ownership to the LSP is necessary for compliance with Swiss laws.

The above illustration shows that the commercial laws of a jurisdiction, and the level of enforcement, determines the environment where contracting occurs. Commercial law specifies the property rights associated with the commercial transaction, and enforcement of these rights determines the confidence of contracting parties in the contract. A jurisdiction's commercial laws should clearly define how a collateral lien can be perfected, how collateral priority is determined, and how notification of a lien is made.

3.6 DISCUSSION AND THEORETICAL EXTENSION

The previous sections indicate that there are several areas in the supply chain where the logistical, financial, and legal perspectives are overlapping, as illustrated in Fig. 3.3. In this section, we discuss and elaborate how the efficiency of international supply chains could be strengthened by studying SCF from an interdisciplinary perspective. Particular attention

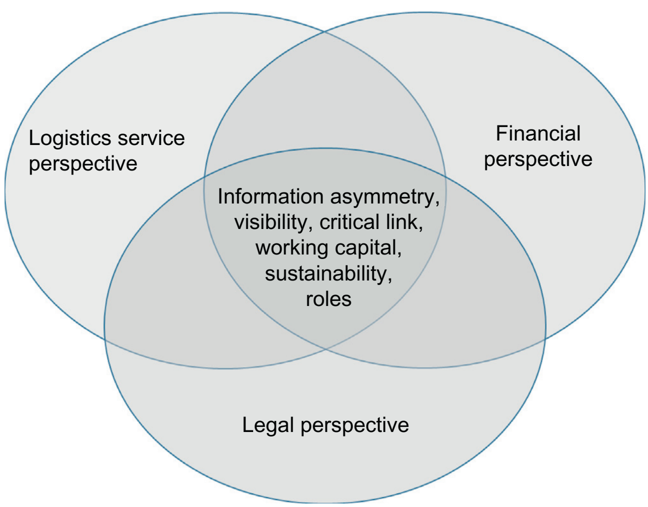

Figure 3.3 Overlapping areas of the logistics service, financial and legal perspectives.

is directed toward how critical links (weakest links) and working capital in such chains are affected by the requirements of greater visibility in order to reduce existing information asymmetry. This has implications for the sustainability of different SCF solutions, as well as the trust between different actors in the supply chain.

The reduction of information asymmetry is crucial for advances in SCF. The development of legal instruments may be necessary to promote SCF throughout the international supply chain. However, the various instruments will have different objectives—whether a fiduciary purpose, the promotion of international trade, or other socioeconomic policies.

The WTO Trade Facilitation Agreement (TFA) is a comprehensive trade facilitation reform which consolidates and multilateralizes the commitments of states to create efficient trading processes and procedures at the borders. Article 10 of the TFA mandates that all members of the WTO shall endeavor to establish and maintain a single window enabling traders to submit documentation for export, import, and transit of goods through a single-entry point. The TFA entered into force in February 2017, and once it is fully implemented, WTO Member States will have an operational single window to facilitate import, export, and transit-related regulatory functions. The interoperability of these single windows in the near future is pertinent to the issue of information exchange, as they will lead to the creation of an information exchange channel. This channel allows for dematerialized information to fulfill the trade functions in an electronic business environment, to increase the visibility of global supply chains.

While the WTO TFA creates the overarching legal framework for digital trade and presents the possibility of expanding SCF to the entire supply chain (Basu Bal, Rajput, & Alizada, 2017), other institutions such as United Nations Economic and Social Commission for Asia and the Pacific (UN/ESCAP), United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), United Nations Network of Experts for Paperless Trade and Transport Facilitation in Asia and the Pacific (UNNExT), United Nations Commission on International Trade Law (UNCITRAL), World Customs Organization (WCO), etc. contribute to the supplementary legal framework necessary for the implementation of single windows, paperless trade, etc. In this chapter, the efforts of UNCITRAL are highlighted through a brief discussion of the Model Law on Secured Transactions, the draft Model Law on Electronic Transferable Records, the Rotterdam Rules on international carriage of goods by sea, the ongoing deliberations at Working Group (WG) I on the draft legislative guide on key principles of a business registry to facilitate micro, small, and medium enterprises, and the deliberations at WG IV on contractual aspects of cloud computing and the legal issues related to identity management and trust services. The above instruments are chosen as they can promote SCF through better security for lenders and the increased visibility of global supply chains.

The UNCITRAL Model Law on Secured Transactions is based on the UNCITRAL Legislative Guide on Secured Transactions. The Model Law is intended to assist States in developing modern secured transactions laws with a view to promoting the availability of credit. Taking a security interest enables a creditor to have priority over competing creditors if the debtor files for bankruptcy. The Model Law is developed as concise text, to be used as a tool for implementation of the Guide's recommendations and setting out a regime for secured transactions. Many of the solutions provided in the Model Law are inspired by Article 9 of the US Universal Commercial Code (UCC), which governs security interests and applies to any transaction that creates a security interest in personal property. The Model Law provisions integrate the treatment of all transactions fulfilling a security function and the replacement of a wide range of security devices with a single concept, the security interest. Under the Model Law, a security interest can be made effective against third parties by registration, by the taking of possession or, in the case of financial collateral, the taking of control. The notice filing through registration can be done in advance of the security being created, so that the register is then a warning that a security has been or may be taken. Only one filing is required for all transactions between the same parties involving the same kind of collateral. The priority rules of the Model Law are designed to produce a commercially reasonable outcome for typical disputes. Filing is a priority point, in that priority between security interests generally depends on the date of perfection.

It is now well known that electronic records promote dematerialized information exchange. Large enterprises see value in using electronic data interchange provided by large LSPs, such as DHL or UPS. These large LSPs have their enterprise resource planning (ERP), transport management and logistics systems that are connected to the ERP system of the large enterprise at one end and with customs' and port authorities' interfaces on the other end. Generally, small and medium enterprises (SMEs) do not have advanced internal ERP systems and do not use the services of such large LSPs. They continue to use a mix of electronic and paper-based information and documentary exchange, which puts them at a competitive disadvantage vis-à-vis the large enterprises. Moreover, SCF is not efficiently extended to SMEs as they are outside the range of electronic visibility.

It is important to increase visibility for SMEs by reducing information asymmetry. Information asymmetry has been a challenge for SMEs when they seek finance to fuel their growth. Since the 1960s, private sector finance has played an increasingly critical role in driving economic growth. However, lesser disclosure requirements and often, shorter formal trading history make it harder and more expensive for investors and financiers to acquire the required information to make accurate assessments about creditworthiness. As a result, SMEs continue to find it hard to get the finance they need to participate in the formal economy and international trade. Also, stringent banking regulations have further excluded SMEs through "know your customer" (KYC) and antimoney laundering (AML) requirements. Lack of visibility prevents SMEs from providing the information required by banks to grant access to debt. Also, SMEs are not able to signal to the trading partners their quality as suppliers. For the past several years, regulators around the world have recognized that jurisdictional disclosure and registration measures need to be redesigned to encourage SME trade participation and boost economic growth. Several options have been designed in various parts of the world to break down information asymmetry at the outset of market entry. UNCITRAL WG I is currently deliberating on legal issues surrounding the simplification of incorporation and to good practices in business registration, both of which are aimed at reducing the legal obstacles encountered by SMEs throughout their life cycle. It is submitted that this initiative along with other initiatives such as a global identifier system can increase visibility and enhance the chances of funding for SMEs.

Liability rules on cloud computing and identity management are necessary for collaboration on a collective basis. In November 2016 UNCITRAL WG IV started its deliberations on cloud computing, identity management, and trust services. For banks the identity of the counterparty is of fundamental importance, as it is necessary for verifiability and other regulatory reasons, such as KYC and AML requirements. There are several legal concerns for the identity provider, relying party, and the user/data subject. Major among them is liability. Other concerns may relate to data integrity, e-contracts and e-signatures, cyber security law, privacy and data protection law, dispute resolution, etc. Since the deliberations have just started, there is room for much discussion on this subject in the near future.

3.7 CONCLUSION

We set out to move beyond the idiosyncratic and somewhat narrow analysis of SCF that tends to focus on dyadic settings, one (or a few) single actor(s) or modeling the short-term benefits of SCF. We argue that while these studies have great merit, it is imperative to adopt the broader supply chain perspective. Moreover, the expansion of SCF programs throughout the supply chain has to be supported by a robust legal framework. If it is, it can result in greater financial inclusion, with the potential to raise SME visibility to improve confidence and transactional efficiency, freeing up capital and other resources to invest in productive output.

With the exception of the TFA entering into force in 2017, the multilateral trade negotiations are moving at a glacial pace. The new business realities such as digital trade and global supply chains need quick action from policymakers. Multilateral initiatives are possibly not well suited to deliver for digital trade in the short run, as many states do not want to commit themselves to such evolving areas without fully understanding the implications. The need for expanding the scope of SCF to support SMEs is an immediate problem. Therefore, private law solutions will dominate in the short run and UNCITRAL is possibly the most suited institution to create harmonized laws that can facilitate SCF. The UNCITRAL instruments and initiatives discussed above are new and therefore it can be hoped that States will soon start using them in creating or updating their national legislation.

As the providers of finance and new financial solutions, banks and other financial service providers are likely play a major role in this process, but such players are constrained by the lack of information. In particular, as banks continue to dismantle their branch networks, other actors may step in to provide the invaluable soft information that is needed to provide competitive financial solutions. It has been argued here that the LSPs, through their local presence and understanding of the physical and informational flows, have a major role to play.

In this vein, we propose that the use of financial technology supported by efficient legal structures and relevant informational channels creates an important opportunity for policymakers, working together with industry stakeholders, to deliver highly usable policy outcomes and provide benefits for collaboration between the physical and financial layers of the supply chain.

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CHAPTER 4

Modeling Risks in Supply Chains

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Russian novelist Leo Tolstoy wrote, "Happy families are all alike; every unhappy family is unhappy in its own way." This so-called Anna Karenina Principle applies to supply-chain disruptions in that every disruption comes with its own roster of causes, its own cascade of effects, and its own litany of misery.

More than two decades of research—culminating in two books: *The Resilient Enterprise* (Sheffi, 2005) and *The Power of Resilience* (Sheffi, 2015)—have traced the increasing numbers of ways that companies' supply chains can be unhappy. Factors such as rising global trade, a growing middle class in developing countries, outsourcing, and increasing product complexity have all contributed to an expanded geographic risk footprint of many companies. At the same time, rising global competition, lean manufacturing, natural resource constraints, and consolidation of suppliers in some industries have made organizations more vulnerable to remote disruptive events.

Models of supply-chain risks often start with simple actuarial or theoretical models of the likelihood and impact of root causes of damage to the company's own facilities from fires, floods, earthquakes, and so forth. Next, the models extend to include the sites of suppliers. Third, understanding some categories of risks also entails understanding deeper supply-chain structures into which there is far less visibility on specific sites and vulnerabilities. With these three levels comes an understanding of how disruptions arise and propagate in supply chains; this understanding, in turn, enables companies to develop both quantitative and qualitative insights into the likelihood and impact of disruptions so that they can prioritize their risk management efforts.

This first section of this chapter provides a classification of disruptions that can affect supply-chain operations, from natural disasters to accidents to intentional disruptions to global crises. The second section focuses on

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mapping such disruptions according to their likelihood and potential impacts, so planning can be prioritized. The third section is focused specifically on supply risks, including explanation of modern alert systems. The fourth section describes the concept of value-at-risk in terms of the importance of certain suppliers and customers to the company. The fifth section characterizes supply-chain structure in terms of the potential risk they pose and the last section portrays industry trends in terms of their impact on supply-chain risks.

4.1 A MENAGERIE OF MISFORTUNES

Before organizations can model risks for purposes of risk management, they need to examine the gallery of possible risks. Supply chains, with their complex global connections and diverse stakeholders, can have many failure modes. Disruptions might be tied to natural, negligent, or intentional causes. Disruptions might involve suppliers, workers, customers, competitors, the built environment, the natural world, governments, and nongovernmental organizations (NGOs). Root-cause events may strike a company directly, or they may strike a deep-tier supplier or a customer's customer.

4.1.1 Natural Disasters

Ash from a volcano in Iceland in 2010 grounded air traffic across the European Union and, consequently, devastated fresh food and flower exporters in Africa. A 2011 flood in Thailand inundated 877 factories (Baker & Lui, 2012), halted 30% of the hard-disk manufacturing industry (Punter, 2013) and caused billions of dollars in losses for the PC industry. A drought in the US Midwest in 2012 damaged crop yields, sent crop prices soaring, and hit food producers, especially meat and dairy producers (Taylor, 2012). Each year, nature can thwart companies dependent on the smooth operations of their global supply chains.

In total, natural disasters created $380 billion in losses in 2011 (Losses, 2012). That year saw an especially severe litany of floods, hurricanes, earthquakes, and tsunamis. These events killed people, damaged property, disabled logistics infrastructure, and upended the lives of citizens and employees, and entire industries. Annual surveys of businesses (Business Continuity Institute & Zurich, 2009–2013) in 2009–2013 found that 50% of companies suffer supply-chain disruption from adverse weather in any given year. Weather is consistently the first or second most common cause of disruption. In addition to disruptions from adverse weather, about 20% of companies experience a supply-chain disruption from an earthquake or a tsunami in any given year.

4.1.2 Accidents, Safety Violations, Noncompliance, and Fakes

Disruptive accidents, often caused by lax safety measures, run the gamut from massive conflagrations to simple failures in critical pieces of equipment. An explosion at a German chemical factory, for instance, caused carmakers around the world to suddenly face potential disruptions of thousands of different parts used on every vehicle they made (Trudell, Kishan, & Naughton, 2012). When a barge on the Rhine River capsized, the river was closed for 20 days, delaying 450 barges and hindering the 170 million metric tons of goods shipped on the river annually (Havoc, 2011). In a third example, a toymaker suffered a highly publicized recall of 1.5 million lead-tainted toys after a paint supplier to a contract manufacturer had to find a second source for pigments but did not have time for testing (Mattel's, 2007). Such accidents and safety violations can disrupt logistics infrastructure, manufacturing equipment, and the flow of goods or parts, undoing many years of reputation building and brand loyalty.

Counterfeits and fraudulent substitutes also bedevil some supply chains. In January 2013 the Food Safety Authority of Ireland shocked Europe with an analysis of 27 hamburger products, 10 of which tested positive for horse DNA and 23 that tested positive for pig DNA (Smith-Spark, 2013). Electronics for the US military have likewise suffered from thousands of cases of counterfeit electronic components (Carson, 2011). In civilian aviation, about 520,000 counterfeit or unapproved parts make their way into planes each year, according to the Federal Aviation Administration (American Institute of Aeronautics and Astronautics, 2008).

Whereas natural disasters occur regardless of the preparations and vigilance of companies, disruptions such as accidents, violations, and counterfeits are less likely for companies that become well prepared and attentive. Utilizing safety programs, intensive quality control, and prudence can reduce the likelihood of these problems. Nonetheless, the connectivity of supply chains and companies' dependence of shared resources such as key raw materials or key transportation lanes implies that even the most careful company can be disrupted by the imprudence and bad luck of others.

4.1.3 Intentional Disruptions

Intentional disruptions come in many forms. In November 2012, for example, 400 office clerks walked out on their jobs at the ports of Los Angeles and Long Beach, thereby halting the movement of $760 million a day worth of goods. The 8-day strike held up an estimated $6 billion in shipments (What is, 2012).

In 2010, to protest the destruction of tropical forests for the farming of palm oil, Greenpeace raided Nestle's annual shareholders' meeting; activists dressed as orangutans stood outside Nestle's headquarters in Frankfurt, Germany, while other activists unfurled a banner inside the meeting itself (Greenpeace, 2010).

Intentional disruptions include attacks on a company's assets or processes, with the goal of disrupting its operations or robbing it. These disruptions comprise criminal acts like cyber-disruptions (such as denial-of-service attacks and theft of customer data), cargo theft, extortion, kidnapping, embezzlement, sabotage, and corporate espionage, as well as legal actions such as labor strikes, management lockouts, and activist boycotts and protests. Intentional disruptions are fundamentally different from natural disruptions or accidents because they specifically target the least protected entity at the worst possible time. For example, in 2005, terrorists attacked the lightly guarded London subway and bus system rather than the more heavily secured Heathrow Airport.

4.1.4 Creative (and Otherwise) Destruction

Beginning with Apple's iPhone in 2007, the rise of touchscreen smartphones coupled with app stores decimated the sales of previous mobile phone industry leaders such as Nokia, Blackberry, and Motorola. In the 1980s the fruits of the Toyota Production System outcompeted American carmakers on cost and quality (Pollack, 1994). In his groundbreaking book, *The Innovator's Dilemma*, Christensen (2011) lists many other examples of new products and business processes that disrupted existing ones, from the transistor radio to LCD TVs to steel minimills. Such innovations cause existing firms to cede their market leadership, lose profits, and even disappear.

4.1.5 Global Crises: An Age of Contagion

In 1997 a crash in the price of the Thai currency created a financial contagion that swept through Asian economies (IMF, 1998) and caused crises in financial markets in the United States, Europe, Russia, and Latin America (Timeline, 1997). In 2008 a housing bubble led to a foreclosure crisis that threatened to collapse the world financial system like a house of cards. Marked contractions in credit supply and consumer demand triggered a global bullwhip as imports plummeted, causing contractions and bankruptcies throughout global supply chains.

Nor are financial contagions the only causes of global crises. In 2003 severe acute respiratory syndrome appeared in Asia and rapidly spread to more than two-dozen countries on the wings of global air travel (CDC, 2003). Ten years later, health officials began monitoring a related disease, the Middle East respiratory syndrome (CDC, 2013). And in 2014 governments around the world took steps to stop the spread of the Ebola virus (Sun & Fairfield, 2015). Each year, health officials also worry that new strains of flu threaten to reenact the 1918 Spanish Flu pandemic that killed 50−100 million people worldwide (World Health Organization, 2013). In addition to the potential human toll, epidemic diseases threaten to curtail the free movement of people and goods that underpin global supply chains (Mass, 2003).

Last, there are internal and external political upheavals. A dispute between the governments of China and Japan over the ownership of a group of uninhabited islands led to a Chinese boycott of Japanese goods, resulting in a 17% drop in value of Japanese exports to China between June and November 2012 (Perlez, 2013). Following a 2014 decision by China to move an oil rig into disputed waters with Vietnam, Vietnamese mobs ransacked foreign factories, causing manufacturers around the world to halt production (Sevatopulo, Peel, & Grant, 2014). In 2011, Spanish fruit and vegetable exporters lost €200 million/week after a food poisoning scare caused Germany to ban Spanish cucumbers (BBC, 2011). The growing interconnectedness of the global economy makes it increasingly prone to contagion.

4.2 QUADRANTS OF CATASTROPHES: IMPACT AND LIKELIHOOD

The preceding anecdotes and surveys of business disruptions illustrate two key points that affect how companies prioritize risk management efforts. First, different disruptions have different degrees of impact. For example, a tsunami that sweeps a factory into the sea is more serious than a shortage of some part. Second, different disruptions occur with different

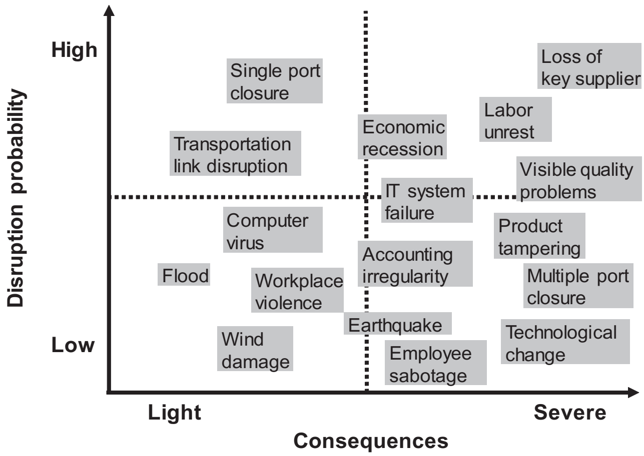

Figure 4.1 Prioritizing possible events.

frequencies or likelihoods. Adverse weather occurs more frequently than do major fires, epidemics, or disruptive innovations.

Thus, many risk experts categorize potential disruptions by their impacts and their likelihoods, such as shown in the 2×2 matrix in Fig. 4.1. This stylized example shows where various hypothetical types of disruptions might lie on the four quadrants of impact and likelihood. The figure depicts events defined by causes (e.g., flood, wind damage, recession) as well as events defined by their supply-chain disruption (e.g., loss of key supplier, IT failure, and downed transportation link).

4.2.1 Estimating Impact and Likelihood

Companies can estimate the impacts and likelihoods of disruptions using a range of historical, analytic, or subjective methods. The potential impact can be estimated in terms of days of sales, dollars of revenue loss, operating income reduction, brand diminution, stock price reduction, and/or loss of market share. Although the impact of a downed plant or supplier disruption may be the same regardless of the cause, estimating likelihood entails examining the possible causes of the disruption and the chances of each of them occurring.

For any given business location, data and models regarding seismic activities, hurricanes, tornadoes, wind, and floods can be used to estimate a statistical distribution of frequency and severity of natural disasters for that location. Actuarial models of fires, accidents, crime, and other damage claims offer insight into the diverse risks to property and equipment in different geographies. Analysis of political, social, and economic risks can elucidate some of the relative risks linked to facilities in different locations. Overall, these spatial models of risk can help estimate the chance of particular facilities in particular locations being damaged or impaired by any of a wide range of natural or man-made hazards. These location-based risk estimates underpin the organization's *geographic risk footprint*.

In the absence of good data and rigorous estimates of impact and likelihood, however, some companies use more subjective scoring methods. For example, a large beverage company divides impact and likelihood each into five levels, creating a 5×5 matrix (rather than the 2×2 matrix shown in Fig. 4.1). Furthermore, they assign nonlinear numerical values to the levels. The company assigns a relative numerical score of 1, 3, 7, 15, and 31 to the five levels of impact (the horizontal axis) and a relative numerical score of 1, 2, 4, 7, and 11 to the five levels of likelihood (the vertical axis). The rationale for this pattern of levels is that impacts (e.g., "What happens if Supplier X can't ship for 2 months?") are often easier to assess than likelihoods ("What is the probability that something will disrupt Supplier X?") and therefore are given a higher weight.

The company then multiplies the impact and likelihood numerical scores to compute a total risk score, which can range from 1 (for insignificant risks with both low likelihood and low impact) to 341 (for perceived "worst-case" risks with both high likelihood and high impact). This number is, in fact, a mathematical expectation of the damage from a disruption, and the assumption is that the higher the expectation, the more resources should be directed toward mitigation and resilience. The design of the scales also means that high-impact/low-probability events will have a higher risk score than high-probability/low-impact events. As discussed later in this chapter, however, the worst-case disruptions may not be the highest-expected-value disruptions.

4.2.2 The Power Law of Impacts Versus Likelihoods

Although Fig. 4.1 depicts each type of event such as "earthquake" as having a specific likelihood and impact, actual events range across a spectrum of likelihoods and impacts. In the average year, seismologists tally about 1300 earthquakes of magnitude 5–5.9, which are strong earthquakes capable of causing damage. They also detect an average of 134 earthquakes of magnitude 6–6.9, which are quakes that have 32 times the destructive energy but are about one-tenth as likely to occur than the

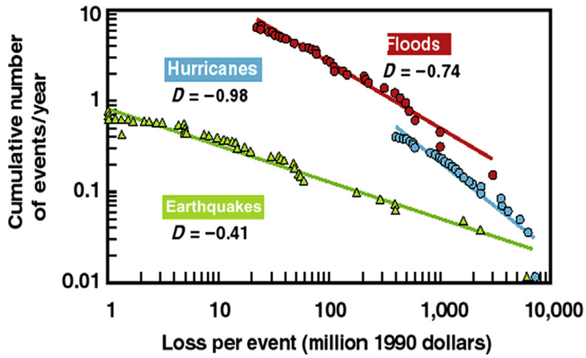

Figure 4.2 Hurricane and earthquakes losses 1900–89; flood losses 1986–92. *US Geological Survey, https://pubs.usgs.gov/fs/natural-disasters/.*

magnitude 5–5.9 quakes. Finally, seismologists record about 15 quakes of magnitude 7–7.9, which are another 32 times more energetic and approximately another one-tenth as likely (USGS, n.d.). This multiplicative mathematical pattern of increasing destructive magnitude and decreasing likelihood is known as a power law distribution. The power law distribution is also known popularly as the 80/20 law, which posits that 80% of the damage comes from 20% of the events.

As it turns out, many types of disruptive events—including earthquakes, volcanoes, hurricanes, tornados, floods, landslides, forest fires, power outages, and even man-made events such as terrorist activities, cybercrimes, wars, and commodity price volatility—generally follow a power law. Fig. 4.2 presents, for example, the cumulative number of events for earthquakes, hurricanes, and floods in the United States over a 90-year period versus the loss per event on a log–log scale (Ayyub & Amin, 2007).

4.2.3 The Irony of Anxiety About Expected Losses

The overall priority of each risk depends on both impact and likelihood. As mentioned earlier, risk managers typically prioritize risks based on the expected value of the loss, which is impact multiplied by likelihood. In Fig. 4.1 quadrant terms, the upper right corner high-impact/high-likelihood risks have the highest priorities, the lower left corner low-impact/low-likelihood risks have the lowest priorities, and both high-impact/low-likelihood and low-impact/high-likelihood risks have intermediate values. Expected value, however, may give a biased view on risks.

Well-known *high-impact/high-likelihood* risks are often ones for which the organization has experience and well thought-out "playbooks." Each year, the Atlantic Basin brews up an average of 12 named tropical storms, including six hurricanes (Landsea, n.d.). The 600 manned oil platforms in the Gulf of Mexico face a high chance of disruption every year and have well-rehearsed procedures for shutting down production and evacuating personnel (Henry, 2012). Organizations plan for the expected (e.g., hurricane seasons) because their likelihood is historically high or they have seen them hit before.

But the irony of using expected losses to prioritize risk is that it leaves the company open to high unexpected losses. Although airfreight companies in Europe had contingency plans for handling the shutdown of any airport in Europe, they did not expect the 2010 Eyjafjallajökull volcanic eruption that closed down almost every airport in Europe, disrupting a wide range of imports and exports such as green asparagus from the United States, fresh fruit from Italy, French cheeses to Asia, and car parts for global manufacturers. Thus, *high-impact/low-likelihood* may be more dangerous than their expected value implies because companies are less prepared to deal effectively with them.

Of course, the term *high-impact/low-likelihood* is relative. As the power law indicates, the likelihood of specific very high-impact events may still be very small. Yet globalization has increased the length, breadth, and complexity of supply chains. Although low-likelihood events are individually unlikely, global enterprises are now exposed to large numbers of unexpected events through all their complex and lean networks of suppliers. In other words, the probability that a specific disruption will take place in a specific supplier's facility on a specific day may be very small. Yet, the probability that something significant will happen somewhere in a global supply chain sometime during a given year may be quite high. "I have 14,000 suppliers. I guarantee that with 14,000 suppliers, at least one of them is not performing well today," said Tom Linton, chief procurement and supply-chain officer at Flextronics (personal communication, July 30, 2012).

4.3 ASSESSING SUPPLIER RISKS

Supplier risk assessment can use the same models of likelihood and impact but evaluates these models on each of a company's suppliers, their facilities, and their inputs to the company. As mentioned earlier, disruption likelihood can be estimated using models based on past data for natural disasters, as well as qualitative estimates of political risks, labor relationships, and other man-made disruptions. The likelihood of disruption of a given supplier or supplier facility depends on the combined likelihoods of causes such as earthquakes, fires, labor strikes, and so forth. Supplier risk models also include two additional types of risks not typically modeled for the company's own facilities: bankruptcy risks and reputation risks.

4.3.1 Supplier Bankruptcy Risks

First, suppliers can go bankrupt. Macroeconomic changes such the 2008 recession changed how companies model and monitor supplier risks. A manager at an energy company noted that, "Before the financial crisis, we didn't have a very professional assessment of our suppliers' financials; now we have a very good system working" (Blome & Schöenherr, 2011). In the case of suppliers that are listed on the stock market, quarterly financial reports offer data on financial conditions. In the case of smaller, private suppliers, third-party assessments and supplier surveys provide such data. Specific functions within an enterprise may handle specific suppliers' risk assessment tasks, in collaboration with procurement professionals. For example, the finance department typically assesses the financial health of suppliers to estimate the risk of bankruptcy—by using methods similar to the financial risk scoring of customers—in order to decide appropriate payment and credit terms.

4.3.2 Reputation: Why No Supplier Is "Low Risk"

Second, a different kind of supplier-related disruptive risk hits companies that operate on the demand side more so than the supply side. Even suppliers with a low likelihood or low impact of supply disruptions can still present significant risk if the supplier's actions (e.g., child labor, toxic emissions) can damage the reputation of the company. Reputation risk arises from a company's exposure to any supplier's corporate social responsibility (CSR) transgressions. For example, in 2007 Greenpeace attacked Unilever, Nestle, Kraft, and others over the use of palm oil linked to deforestation and loss of habitat for orangutans in Indonesia and Malaysia (The campaign, 2010). In 2010, ForestEthics began a campaign against US brand-name retailers and consumer goods companies, to pressure them to boycott fossil fuels derived from Canadian tar sands or oil sands (McDonnell, 2011). After the collapse of the Rana Plaza garment factory killed 1130 workers in Bangladesh in 2013, labor activists and NGOs renewed criticisms of Western apparel makers and retailers over suppliers' labor practices (Ross, 2015).

As a type of intentional disruption, a company's risk of being attacked depends on the attackers' perception of the company's vulnerability to attack. Consumer-facing companies are especially sensitive to brand reputation issues, which is why activists typically attack large consumer brand companies rather than the suppliers or middle-tier business-to-business companies that may be guilty of perceived social responsibility misdeeds. More importantly, unlike risks of supply disruption—which can be mitigated by using more suppliers—risks of reputation-related demand disruption grow as more suppliers are added.

4.3.3 Double-the-Sources, Double-the-Headaches

Although some supplier risk models assign a lower risk to dual or multi-sourcing because the chance of both or all suppliers being disrupted is lower than the chance of a single supplier being disrupted, at least two types of risks increase in likelihood if the company adds more suppliers. First, both Intel and GM are somewhat ambivalent, even circumspect, about dual sourcing because second sources can increase product quality or manufacturing yield risks even as they reduce supply disruption risks. Intel alluded to a kind of alchemy that enables unique, sole-sourced chemicals to do their magic. The chipmaker noted that second sources are never identical, which increases the risks of yield or quality problems. Similarly, GM likened the casting of metal to an art rather than a common process, which motivates GM to sole-source certain parts despite the risk.

Second, CSR risks also worsen under multisourcing. The more suppliers a company has, the higher the chance that one of them (and it only takes one wayward supplier to create a problem) might get caught in a CSR scandal involving issues such as environmental damage, child labor, worker rights, or political issues. The UN IDO (2002) noted that larger companies often rationalize their supply chains to a smaller number of large suppliers that are easier to monitor. Tighter relationships with smaller numbers of suppliers can also help control other kinds of disruptive risks, making sole source less risky than a simple risk model might predict.

4.3.4 A Fragile Web of Connections

A supply chain's geographic risk map includes more than just the factories and warehouses of the company and its suppliers. Another significant geographic risk for global supply chains occurs in the logistical connections between geographically dispersed nodes of the company, its suppliers, and its customers. Although, in theory, shipments between any two points could take any of a large number of routes—creating a risk-reducing diversity of options—the economics of conveyances and distribution favor more concentrated hub-and-spoke topologies. The statistical distribution for the size of sea ports, for example, also follows a power law (Bichou, Bell, & Evans, 2014), implying that a small number of large ports carry an outsized fraction of all trade and create an outsized risk of disruption.

The effects of an April 2010 eruption of a modest-sized ice-capped volcano in southern Iceland illustrate the diverse impacts of logistical disruptions. The eruption's resulting ash cloud forced the closure of major airfreight hubs such as Heathrow, Amsterdam, Paris, and Frankfurt for up to 5 days (Volcanic, 2010). In the United Kingdom alone, airfreight handled 25% of all imports (Wray & Wearden, 2010) and 55% of exports to non-EU countries (Lee, Preston, & Green, 2012).

The disruption of these logistical linkages propagated to both suppliers and customers dependent on EU airfreight. In Kenya, during the 6 days of airport closures, thousands of tons of fresh flowers rotted in storage units and warehouses, representing a loss to the Kenyan economy of $3.8 million per day (Lee et al., 2012), which represented about 3% of Kenya's daily GDP (CIA, n.d.). Italian exporters of mozzarella and fruit lost about $14 million each day that flights were grounded. The Federation of Hong Kong Industries said hotels and restaurants in Hong Kong had shortages of Belgian chocolates and Dutch fresh-cut flowers (Iceland volcano, 2010). Migros, the Swiss supermarket chain, noted disruptions in inbound supplies from Southeast Asia (tuna). Three BMW plants in Germany could not get inbound parts from Asia (Iceland volcano, 2010). And an inability to ship transmissions out of Europe disrupted production at BMW's US factory (Bell, 2010).

Airfreight is not the only vulnerable mode and volcanoes are not the only risk that can disrupt bottleneck transportation hubs or routes. The Rhine River carries 16% of Germany's trade (Transatlantic Outreach Program, n.d.). Recurring droughts (More misery, 2009), an overturned barge in 2011 (Associated Press, 2011), and finding unexploded bombs from WWII (Day, 2011) have all created constrictions in freight volume on the river. In the United States, a quarter of all rail traffic and half of all intermodal rail traffic pass through Chicago, which ground to a standstill during a 1999 blizzard. "We basically waited for the spring thaw," said David Grewe, a supervisor for Union Pacific Railroad (Schwartz, 2012). Modeling these disruptions involves understanding the accidental, intentional, and weather-related seasonal factors that impede the flow of goods through key locations between facilities.

4.3.5 Mapping the Deeper Supply Chain

Many risk models for both natural and man-made disruptions have a strong geographic component, which means the locations of supplier's facilities are a prerequisite for modeling risk. One challenge with assessing location-related supply risks is that supplier master data in SAP, Oracle, or other enterprise requirement planning systems generally includes only the suppliers' administrative addresses or headquarters—not the more crucial operational facilities. A second challenge is the dynamic nature of supply chains, with constant turnover in the supply base as well as the locations used by suppliers for any particular part.

Mapping becomes even more challenging as a company tries to estimate risks from suppliers-of-suppliers and deeper tiers. "We're trying to understand the subsupply chain wherever it is possible and where our suppliers will share that information," said Jackie Sturm, Intel's vice president and general manager of global sourcing and procurement. A major challenge is the natural reticence of suppliers, because the identity of a supplier's suppliers, the materials they procure, and the relationships between the companies are proprietary and are part of the supplier's competitive advantage. Moreover, as more companies attempt to map their supply chains, suppliers face administrative costs for responding to multiple requests for information.

Risk-alert companies such as Resilinc, Elementum, Razient, and MetricStream represent a new generation of supply-chain software and services companies addressing these risk mapping issues. These companies survey a client company's suppliers to map them, and they keep suppliers' proprietary business data secure. The surveys cover risk management issues such as supplier facility locations, subsupplier locations, business continuity planning, recovery times, emergency contact data, conflict minerals, and other concerns. Then the service uses the client's bill-of-material data and value-at-risk (VaR) estimates (a measure of the potential loss to the company) for each product to cross-reference parts with mapped locations and identify high-risk parts. The software uses data on the supplier locations producing each part, the parts in each product, and the financial contributions of each product to estimate the VaR of each supplier location. These service providers can reduce the costs of supplier mapping and updating because the survey data can be pooled among multiple customer companies, which often have overlapping sets of suppliers.

4.3.6 Supplier Risk Scorecards

To systematically aggregate all this supply risk data, some companies use a multielement risk assessment or scorecard. For example, Boston Scientific Corporation, a manufacturer of advanced medical devices, uses what it calls a Risk Wheel to score event risks and aggregate them into an overall supplier risk probability index. The outer ring of the Risk Wheel lists potential disruptions such as service problems, delivery problems, quality problems, labor strikes, changes of ownership, bankruptcy, natural disasters, and so forth. The company scores each supplier on each risk using a qualitative five-level spectrum from green (very low risk) to red (very high risk). The middle concentric ring organizes risks into broader categories of disruptions—such as performance, human resources, financial—with a risk score aggregated from the risk scores of the events in the outer ring. For example, potential quality, delivery, and service problems in the outer ring are aggregated into a "performance" category of risks in the middle ring. The center is the aggregate risk score, called a risk probability index (Boston Scientific Corporation, 2007). This probability index is combined with the revenue-at-risk (described in the next section) for that supplier to determine the total exposure of the company to the supplier under consideration.

Insurance company Zurich's supply chain risk assessment includes 23 risk grading factors, most of which reflect supply-side risks at three levels: (1) the supply-side industry, (2) the supplier, and (3) the supplier facility. Zurich's assessment uses a detailed risk evaluation of each key supplier. The evaluation includes 77 in-depth questions focused on seven areas: the relationship to the company, quality systems, risk management practices, labor and skill levels, operations details, physical environment, and the supplier's own supply chain.

4.4 PRIORITIZING SUPPLIERS BY RISK

Given that large companies can have thousands of suppliers providing tens of thousands of different subassemblies, parts, materials, software and services, many companies focus their risk modeling and risk management efforts on "key" or "critical" suppliers, defined by some metric. Supplier prioritization metrics can include the importance of the material to the company, the availability of alternative suppliers, the speed with which a change (in supplier or material) could take place, total "spend" (total amount of money given to that supplier in a time period), supplier location, or a more formal analysis of the supplier's financial contribution to the company's business. The vast majority of supply-chain risk managers within the companies surveyed by the Business Continuity Institute (81%) say they have identified all or almost all of their key suppliers, which is the first step in such an analysis (BBC, 2011).

4.4.1 Value-at-Risk: Linking Suppliers' Contributions to Products

"Some supply chain professionals measure the importance of a supplier by the 'spend'," said Nick Wildgoose, global supply-chain product manager for Zurich Financial Services Group. Yet Gerry Smith, senior vice president of global supply chain at Lenovo said, "Companies shouldn't overlook the risk of losing a vendor that makes basic yet essential parts. The loss of either could result in a significant supply chain disruption" (Economist Intelligence Unit, 2010). For example, when the 2010 Iceland volcanic eruption closed European airports, Nissan's inability to fly $30 air pressure sensors from Ireland to Japan kept the carmaker from producing $30,000 Nissan Murano SUVs (BBC, 2011). Thus Wildgoose advises a supplier risk assessment "driven from a top-down approach: what is our most profitable product or service and which suppliers do we rely on to drive that" (Zurich, 2011).

One such example is Cisco's Global Component Risk Management (GCRM) process. Cisco makes more than 10,000 products from more than 60,000 parts sourced from more than 1000 suppliers. Only a relatively small number of these products, however, generate the majority of the company's revenue. These are the most critical products. By extension, some parts—and thus some suppliers—are more critical than others because they are used in those top products or in multiple Cisco products, which are together responsible for a significant fraction of Cisco's revenue. GCRM periodically assesses the risk of each such part based on its sourcing status (single vs multisourced), quality history, technology status (legacy vs new) and life cycle (new, continuing, end of life) (Harrington & O'Connor, 2009). The analysis is used to prioritize and prepare risk mitigation strategies for the risky parts.

This notion of the link between suppliers and products gives rise to supplier disruption risk models based on VaR that estimate the financial damage to the company from a supplier disruption. This method uses data from the Bill of Materials and Enterprise Resource Planning system to determine which products might be affected by a given supplier disruption, the fraction of production affected (if the supplier is not sole source), and the daily value of those products to the company as measured by metrics such as revenue, margin, market share, and so forth. Multiplying the duration of the likely supplier disruption in days times the daily value of impacted production (or sales) computes the likely financial hit from a disruption of that supplier.

4.4.2 Consider the (Sole) Source: Prioritizing Key Suppliers

Highly quantitative risk models such as VaR require a fair amount of data about products and suppliers, including estimates of the likelihood and duration of disruptions for each supplier. For some types of risks, a simple proxy can estimate the likelihood or potential impact and support prioritization. To quickly prioritize the risk of supplier bankruptcies during the financial crisis of 2009, Boston Scientific Corporation identified which components in its product portfolio came from sole source, single source, dual source, or multisource suppliers. The company defined "sole source" as meaning there were no other readily available sources of supply, which may be due to intellectual property issues, technology, a joint venture, or a contract (Boston Scientific Corporation, 2009). It defined "single source" as meaning there were other suppliers available but the company was currently buying from only one supplier for economic or convenience reasons. More restrictive sources were considered to be of potentially higher impact to the company.

4.4.3 The Impact of Procurement Complexity

The nature of the supplied part can modulate company's estimates of impact because some parts are easier (or harder) to procure from alternative suppliers in the event of disruption of the primary supplier. Some materials are simple to procure, such as diesel fuel for trucks or 6061 aluminum alloy bar stock, because they are widely available commodities with standardized specifications and multiple suppliers. Such materials (and their suppliers) may be considered of lower risk, although examples later in this chapter will show how commodities can also be high risk.

In contrast, some inputs require much more complex procurement cycles due to coordination with the supplier, engineering time for customized parts, lead time for tooling, costly validation of samples, auditing of the supplier, and so forth. Supplied inputs such as custom-molded parts, specialized machine tools, ultra-high purity chemicals, semiconductor chips, and branded ingredients may be expensive, time-consuming, or impossible to second source. In some cases, intellectual property issues—such as a trademarked ingredient or patented component—preclude a second source, forcing a company to reengineer its product to use another supplier's part. Such products and their suppliers have higher risk because the duration of a disruption may be especially long if the company is forced to seek a second source.

4.4.4 The Company's Importance to the Supplier

Another procurement-related risk issue is the company's importance to the existing or alternative suppliers. If the supplier suffers a disruption, the supplier will likely to prioritize its customers for resumption of supplies, and some customers may be low priority, creating a pecking order of customers defined by spend or strategic priorities. For example, both GM and Verifone depend on a variety of electronics industry suppliers. But, many of those technology suppliers pay more attention to cell phone and computer makers who tend to use the latest high-margin products. In turn, other vehicle-making companies such as Caterpillar (construction vehicles) and Deere (farm equipment) feel they play second fiddle to the large automakers who are more important customers to vehicle component suppliers. Even the cell phone makers have a pecking order. For example, cell phone maker HTC "has had difficulty in securing adequate camera components as it is no longer a Tier 1 customer," one unnamed HTC executive told *The Wall Street Journal* (Luk, 2013). In essence, every company is a minor customer to some supplier, and that low-spend or low-priority situation adds to the likely impact of disruption.

Overall, given these diverse sources of supplier risk, companies use multifaceted models for modeling risk and prioritizing suppliers for risk mitigation. For example, Philips buys directly from about 10,000 Tier 1 suppliers and 30,000 service providers; therefore, it needs to focus its supplier risk assessment efforts. To this end, it classifies suppliers based on spend, and procurement complexity, measured by factors such as geography, type of relationship, and business risk. In 2012, Philips identified 497 product and component suppliers and 97 service providers as "risky" using these parameters. These are the suppliers that Philips audits routinely (Philips, 2012). Yet modeling supply-chain risks on a supplier-by-supplier basis may miss certain kinds of very serious deeper risks.

4.5 DEEPER RISKS: COMMERCIAL CONNECTIVITY AND SPATIAL BUSINESS RISKS

Models enumerating the risks to a company's facilities and its direct suppliers underestimate the total risk exposure of the company. A company's total exposure to risks of natural and human-made disasters—its total geographic risk footprint—extends far beyond these direct risks to its own facilities and direct commercial partners, including both suppliers and customers. Most manufacturers have visibility to their Tier 1 and possibly some Tier 2 suppliers, but they have little visibility into deep-tier suppliers. Typically, they do not even know who those suppliers are. A 2011 case example shows that these risks may be more pervasive than they appear.

4.5.1 Suppliers of Parts, Suppliers of Indirect Risks

The effects of the 2011 Japan earthquake on General Motors illustrate the significant risks lurking in the deeper supply chain. The March 11, 2011, magnitude 9 earthquake, tsunami, and Fukushima reactor disaster devastated the northeastern regions of the Japanese mainland. Although no GM facility was directly affected by the quake, the company was immediately concerned about potential disruptions to its 25 Japanese suppliers (out of a total of 18,500 Tier 1 suppliers), which GM's crisis team predicted could impact some 390 parts.

The deeper the team dug, however, the greater the number of disrupted parts they found. After only 1 hour following the first meeting of GM's crisis team, they found another 100 disrupted parts from other suppliers, because some of GM's non-Japanese suppliers had Japanese suppliers. And some of GM's non-Japanese suppliers had other non-Japanese suppliers who had Japanese suppliers. And so on. "The list kept growing.

And every day, it went up. It was a moving target for us," said Rob Thom, manager, global vehicle engineering operations at GM (personal communication, August 2012). From the original 390 affected parts on March 14, the number grew to 1551 parts on March 24, to 1889 on March 29, and to a staggering 5329 on April 13. During the month after the quake, GM discovered an average of 160 disrupted parts each day.

GM's extensive use of electronics—sensors, microprocessors, displays, and actuators—in its cars made the company dependent on Japan's extensive electronics industry. Although a dashboard assembly or antilock brake module might be made in America, some of the components may have come from Japan. Yet electronics were not the only items containing "made in Japan" components or materials. GM soon discovered that almost every type of part on many different vehicles required something from Japan. Xirallic, a sparkly additive made by Merck and used in the paint for the Corvette came from Japan. Special body trim plastics, rubber seals, and gaskets came from Japan. High-tech chrome plating on turbochargers came from Japan. Cooling fans, radiator caps, air conditioner compressors, and many more parts had some tie to Japanese suppliers. And each missing part raised the specter of halting production somewhere in GM's system.

4.5.2 Industrial Clusters as Spatial Risk Concentrators

Many companies use second sourcing or multisourcing to diffuse risk. Computer hard disks use standardized interfaces, making the items easy to procure and to second source (low procurement complexity). Moreover, in 2011, the hard disk industry had five large competitive suppliers to handle the volume (Arthur, 2011). But then torrential rains hit Thailand.

Above-normal monsoons plus five tropical cyclones inundated the lowlands of central Thailand, displacing more than 2 million people, flooding 7510 factories, and damaging 1700 roads, highways, and bridges (Aon Benfield, 2012). The disaster also proved that second sourcing does not always mitigate risks. Central Thailand had become an economic cluster that was making 45% of the world's hard disks and their components (Shah, 2011). Four of the five top suppliers of drives had facilities or key suppliers in Thailand that were disrupted by the flood. As a result, the global PC industry faced a 35% shortfall in disk supplies in the fourth quarter of 2011. The flood even affected Intel's sales of microprocessors because without enough disk drives, PC makers were forced to cut production, illustrating that a company's full supply-chain risk model might include its customers' other suppliers.

Economic clusters arise from a combination of natural economic feedback loops and government economic policy. (The mechanisms and impacts of these clusters are described in *Logistics Clusters* (Sheffi, 2012)). From a risk modeling perspective, clustering increases the vulnerability of companies that rely on products created by cluster members as suppliers or customers. The reason is that many types of disruption can have regional impact, which hits many suppliers in the same industry at the same time, making it more difficult to find alternative sources of supply when so many industry players are scouring the globe looking for the same things. "The floods in Thailand in the fall of 2011 showed us how dangerous it is when a component that is needed at manufacturing facilities around the world is mainly procured from only one region," said Martin Bellhäuser, head of governance framework at Siemens.

"Many organizations are more or less forced to put all eggs in one basket because of the clusters of suppliers for various goods around the globe," said Damien Pang, regional manager, claims, at Allianz Global Corporate & Specialty Asia/Pacific (Allianz Global Corporate & Specialty, 2012). North Korea's belligerent stance toward South Korea threatens 78.5% of the global DRAM market (Eadicicco, 2013). Similarly, Japan makes 100% of the world's supply of protective polarizer film for LCD displays, 89% of aluminum capacitors, and 72% of silicon wafers (Marsh, 2011). Four companies in Japan have a near-monopoly on digital compasses, which are the tiny magnetic field sensors that sit inside almost every new phone, tablet, laptop, and navigation system device (Global MEMS, 2011).

4.5.3 Diamonds in the Supply Chain

That a disaster the magnitude of the 2011 Japan quake had such far-reaching indirect disruptive effects is not surprising. Clearly, many companies depended on Japanese suppliers for many components. Yet some supply chains contain a very specific, deeply hidden indirect risk. On March 31, 2012, a tank filled with highly flammable butadiene exploded in Evonik Industries' cyclododecatriene (CDT) plant in Marl, Germany, killing two workers (Reisch, 2012).

CDT sounds like an obscure chemical, and the fact that it is used to synthesize cyclododecane, dodecanoic acid, and laurolactam may mean nothing to most readers. But CDT is a key ingredient in making PA-12, also known as nylon-12, used for automotive parts, solar panels, athletic shoes, ski boots, optical fibers, cable conduits, and flame-retardant insulation for copper wire. CDT is also a key precursor for making many other chemicals, such as brominated flame retardants, fragrances, hot-melt adhesives, and corrosion inhibitors.

Whereas Japan's 2011 earthquake, tsunami, and nuclear reactor disaster devastated a region, directly impacted thousands of businesses, and dragged on for weeks, the Evonik fire damaged only one part of one factory and the fire was extinguished in half a day. But the Evonik explosion destroyed almost half the world's production capacity for CDT. Worse, at the time of the explosion, CDT supplies were already tight due to its use of nylon plastics in the booming solar panel industry.

Because Evonik was so deep in the supply chain, many users of PA-12, such as automakers, were initially unaware of the event. Yet the effect of the Evonik fire would prove to be very large—jeopardizing supplies of 2000 parts at GM, which was one-third the number of parts that had been disrupted by the far larger Japanese disaster. The impact of Evonik was so large because GM (and other automakers) used PA-12 plastic for a wide range of parts such as fuel lines, brake lines, plastic gears, and housings. The average light vehicle in 2011 used more than 46 pounds of nylon, up from just 7 pounds in 1990 (American Chemistry Council, 2016).

The typical diagram of a supply chain shows original equipment manufacturers (OEMs) perched at the top of a pyramid supported by a fan of suppliers, with more suppliers below them and a reassuring broad base at the bottom. Yet the Evonik example shows that although companies may have many suppliers, some parts of the supply base may converge to a single key supplier at a deeper layer—forming a diamond-shaped supply-chain pattern. The 2011 Japan quake revealed many of these supply-chain diamonds in esoteric but essential chemicals such as bismaleimide triazine (epoxy resin for chip making) (Gartner, 2011), polyvinylidene fluoride (in lithium ion batteries) (Sanchanta, 2011), and ethylene propylene diene monomer (rubber gaskets and seals). "What we've found is that in Tiers 3 and 4, the convergence of underlying raw material supply starts to become really significant," said Intel's Sturm (personal communication, July 31, 2012). Economies of scale can drive consolidation of supply sources deep in the industrial base of supply chains.

4.5.4 Resource Concentrations

A company's commercial connections extend all the way to raw natural resources. Thus, a company's geographic risk footprint depends on the geographic distribution of these natural resources, such as minerals, agricultural products, and fossil fuels. Although many natural resources have a broad base of supply, some key materials are not so widely sourced. For example, rare earth elements are a set of 17 metals that play a crucial role in many automotive, electronic, and high-tech applications. Rare earths go into iPhones, electric cars, wind turbines, solar cells, jet engines, fiber optics, hard-disk drives, compact fluorescent bulbs, and many other products (Cho, 2012). China produces 95% of these elements and in July 2010, the country restricted exports of them, which cut off many companies that make products using these materials (Bell, 2012).

China's 2010 rare earth export policy was but one of many examples of what is called *resource nationalism*, in which governments restrict the availability of commodities produced within their borders. Besides export restrictions, special taxes on mining are another kind of resource nationalism. Countries that announced or enacted increases to taxes or royalties during 2011 and 2012 include major producers such as Australia, China, Democratic Republic of Congo, Indonesia, Ghana, Mongolia, Peru, Poland, South Africa, and the United States (Ernst & Young, 2012–2013). Some 33% of companies in a 2011 World Economic Forum survey ranked "export/import restrictions" as "most likely to provoke significant and systemic effects on supply chain or transport networks" (World Economic Forum, 2012).

Although the scarcity of rare earths or precious metals may not be surprising, other base metals such as aluminum, titanium, manganese, and cobalt could see worsening imbalances of supply and demand in the future (Kirchain, 2012). Such imbalances may create disruptions because some countries' supply chains can be heavily dependent on imports. For example, the United States is more than 90% import reliant for many key minerals such as manganese (100%), bauxite for aluminum (100%), platinum (94%), and uranium (90%) (Humphries, 2013). Other material scarcity stress points in global supply chains include indium (used in computer display panels), silicon (chips and solar power), and wood fiber (paper, furniture, biofuel) (Kirchain, 2010).

4.6 A BIGGER PICTURE RISK MODEL FOR BIGGER RISKS

"The world is so connected that the feedback loops are more intense. Our supply chains are global. Our financial markets are global. So uncertainty in one part of the world infiltrates all parts of the world. These days, there are things that just come shooting across the bow—economic volatility and the impact of natural events, like the Japanese earthquake and tsunami—at much greater frequency than we've ever seen," said Ellen Kullman, CEO of DuPont (Kirkland, 2012). Modeling risks in supply chains include some consideration of the trends that might drive risks higher or create new and unexpected risks.

4.6.1 Growth of Global Trade

A leading driver of this growing vulnerability is the rapid growth of global trade. Global merchandise exports surged from $7.38 trillion in 2003 to $18.49 trillion in 2014, implying that more companies are dependent on geographically distant suppliers and customers (World Trade Organization, 2015). Rapidly declining costs of communications and growing efficiency of logistics are enabling all this trade, with the resulting spatial spreading of supply chains. Companies can more readily work with geographically dispersed facilities, suppliers, and distribution centers on the other side of the world (and become exposed to all the risks associated with those remote locations). Meanwhile, their suppliers are pursing similar outsourcing and global business strategies, exponentially expanding the total geographic risk footprint of every company.

4.6.2 Growth of Product Complexity

A second driver of spreading geographic risks is in the growing complexity of products. For example, automobiles now contain between 30 and 100 microprocessors, with each subsystem of the car having its own controller and software (Charette, 2009; Turley, 1999). And new technology means more than just electronics; products now rely on a growing variety of engineered materials, additives, pigments, and treatments that enable high efficiencies, performance, and market acceptance. "Twenty or thirty years ago electronics were being made with 11 different elements. Today's computers and smartphones use something like 63 different elements," explained Thomas Gradael, a professor of geology and geophysics at the Yale School of Forestry & Environmental Studies (Paramaguru, 2013).

With product complexity comes the need to use more suppliers, who, in turn, may use more suppliers, leading to more complex supply chains. Companies often have little knowledge of these deep-tier suppliers and, in most cases, have almost no influence over them to demand more resilience or adherence to any code of conduct. This trend causes the geographic risk footprint of a company to expand beyond its own facilities to encompass the facilities of distributors and customers downstream in the supply chain as well as to suppliers—at multiple tiers—upstream. Accordingly, significant supply-chain disruptions are inevitable.

4.6.3 Statistical Growth of Ever-Bigger "Big Ones"

The historical statistics of big, rare events hide a curse. No matter how bad the last "big one" was, a bigger one is inevitable. As history rolls onward, the list of major disruptions grows skyward. The next "bigger one" may take a long time to materialize, or it could happen tomorrow; but, unfortunately, the unlikely is not the impossible. With a growing global population and a growing global economy, the biggest disaster will always lie somewhere in the future.

4.6.4 Black Swans

Taleb (2007) popularized the concept of very large and unexpected disruptions called "black swans." These events arise and shock everyone, especially the experts, who are blinded by flawed reasoning about seemingly unprecedented events. The central fallacy that creates black swans is that a *lack of evidence* of a possible disruption does not constitute *evidence of lack* of that possible disruption. Events such as the 9/11 terrorist attacks and the 2008 financial crisis are often cited as examples of these kinds of disruptions. By definition, the likelihood and impacts of a black swan are underestimated (or never estimated) under the mistaken belief that the event cannot happen or is not even conceived of its possibility. Black swans reflect a deeper kind of uncertainty than standard likelihood models because experts misjudge the likelihood of a black swan risk to be zero when, in fact, it is not. In essence, even the most thorough risk model misses some risks.

4.6.5 Modeling Shallow and Deeper Risks

The sweep of examples in this chapter shows that companies can model the likelihood and impacts of a wide range of risks to their facilities, suppliers, and logistics infrastructure. Yet the examples also highlight the limitations of these models in terms of availability of fine-grained data on suppliers, especially those with no direct relationship with the company. Nonetheless, even if exact quantitative models are not practical, companies can understand and prioritize risks at a qualitative level. A company can understand such risks through a deeper understanding of the company's dependency on particular categories of deep supply-chain structures such as those related to natural resources (geographic concentrations, price volatility, environmental reputation risks), labor in developing countries (geopolitical and reputation risks), and technological or specialty materials produced by a very narrow or clustered supply base. Although black swans cannot be pinpointed, their nesting spots in the global economy can be considered, enabling companies to think about both obvious and less obvious risks.

4.6.6 Future Research

Long-term trends such as climate change, political upheaval, new technologies, urbanization, and many others mega-trends mean that the world can expect many more significant disruptions. At the same time, companies and government are beefing up their defenses and their planning. Thus the research community has to keep up with both the risks and the responses (as well as the business opportunities hidden in many disruptions), helping laggard companies be better prepared. An area which can benefit from further research is the development of risk metrics and indices, helping companies assess suppliers, regions, network nodes, and customers in terms of the risk they pose. Such metrics have to be continuously updated, automatically, based on the ever-changing environment.

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CHAPTER 5

The Evolution of Modern Ship Finance

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5.1 BACKGROUND

Humans have used the first kind of swimming support since the Stone Age. What probably started as fishing boats has been moving people, cargo, and merchandize ever since. The first boats are known to exist from 120,000 BC, with proper fishing boats seeing the light after 70,000 BC and from at least 40,000 BC vessels have moved people between continents.

From the belligerent explorations in Persia to the battle of Troy and the Peloponnesian and Punic Wars, from to the battles of Nelson and the theater in World War II on the Pacific, ships have played a crucial role in warfare. These ships have in most cases been ordered, financed, and owned by governments of various kinds.

However, at the same time, the merchant navies have thrived on the courageous forays of business people around the globe. Very little is known systematically about the ways these ships have been owned and financed in cultures as different as China, Phoenicians, Ancient Greece, Ancient Rome, and the Renaissance. Some research has been devoted to ship finance in the industrial age, and more knowledge has been accumulated about the subject only after 1945. This chapter tries to trace the major lines and logics of ship-ownership and ship finance from the early ages until today.

The history of asset ownership was originally entirely driven by the cargo. A cargo needed to be transported, thus it needed a ship. The idea of providing ships or space on ships on a speculative basis has been a relatively modern one. The division of labor, as it has been enhanced by the industrial revolution, changed the shipping industry profoundly—almost as a collateral effect. Raw materials were needed in ever larger quantities

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on the input side. Equally, products became distributed over ever larger networks or trades. So eventually, as we will see, the 19th century saw the advent of a new type of trader and transporter, who had not been part of the value chain. And while the value chain spread further, so the rendering of services around the ship as a means of transport became more sophisticated. Finally, in the middle of the 20th century, financing ships became a profession in itself.

5.2 BEGINNINGS

It can be safely assumed that during the first millennia the ownership of ships was very much determined by who built a boat, vessel, or ship. While we focus in this chapter on ship finance and its development, the history of swimming structures, and their ownership theoretically precede any concepts of finance.

It is important to note though that the dichotomy of merchant vessels (fishing boats, ferries of any kind, and vessels for the transport of cargo) on the one hand and state-owned or state-sponsored ships (navy ships, sponsored expeditions, etc.) on the other hand is a constituting factor of the maritime economy. Orders for newbuildings and ownership of any kind of vessels have been shared between the public domain and private entrepreneurs.[1] In the course of our investigation, we will continuously see both originators in constantly developing roles.

It appears that the ancient city of Ur was not only a birthplace of parts of the Mediterranean and Arabian culture: Ur was for centuries also a commercial hub. The trade with Dilmun, a maritime center close to Bahrain, formed a backbone of trading activities. The trade with mostly agricultural wares underwent strong cyclical variations. From 2500 BC, the trade flourished, while it broke down around 1800 BC. The reason was not a physical drought, but long periods of unfavorable weather. In 1788 BC the ruler Rim-Sin rather wiped out all existing debt (Goetzmann, 2016) and with it the long-established financial system. Moneylending had been a cornerstone of the maritime trade. After Rim-Sin banned any larger financial activities, the maritime trade suffered severely.

[1] Still in the 21st century the governments of coastal states remain often the largest shipowner by number of ships employed.

5.2.1 Athens

The Greek and Roman civilizations refined the economic systems of trade and developed sophisticated financial structures that can be traced by modern archeology. "The Greeks invented banking, coinage, and commercial courts. The romans built on these innovations and added business corporations, limited liability investments, and a form of central banking," explains Goetzmann (2016). Though this is somewhat simplified, as already the greater Syria and Mesopotamia provided similar structures, the observation is certainly useful. The Greek and the Roman empires had in one important aspect the makings of an industrial age: the political centers could not provide enough food and, quite aside from the much reported power struggles, needed to develop a reliable food trade. Faraway provinces and territories needed to produce enough food to export, with ships providing the only viable quantity of transport for such imports to the Greek mainland or Rome.

From the trade hub of Constantinople the Greek city states understood very early on the basic chartering system that prevailed from the 7th century onward in the Eastern Mediterranean. One or most often several merchants chartered a ship including the crew and navigator. They elected a captain to represent their commercial interests and sent the ship off with their merchandize. Profits were divided at the end of the voyage.

With a large number of court proceedings on grain and the maritime trade that have been conserved over the centuries from ancient Athens, Goetzmann (2016) argues that these juridical fights have created at the time not only financial literacy for many, but also a sense that risk can be priced, that money has a time-value and that businesses can be used as collateral for money lent.

However, it must be noted that maritime finance at this time was simply trade finance, which included the ship. Merchants accumulated private investors to finance their dealings. Once they had enough money, they could build or buy a ship and prefinance the merchandize. If the ship made the backhaul safely, e.g., with wheat, barely, or other grains, profits could be shared between the investors. Sophisticated legislation defined the markup prices that were allowed.

With the absence of an independent insurance structure that could have been employed, the financial investors in the Greek maritime trades were left to themselves. Or they were rather taking on the role of a mutual insurance structure in themselves, the so-called bottomry. Essential to this structure is that the lenders were rewarded with a share in the profits, but if the ship was lost the borrower did not have to repay the debt (van Wees, 2013). The hypothecation ended if the ship was destroyed.

In today's terms, lending money to the maritime trade appears as a hybrid of equity and debt. The investors did not become partners in the sense of equity capital injection, and they were to receive a predefined interest rate (often between 20% and 30% for a single voyage) and should also receive their principal back (Millett, 2002). However, they shared risks like equity partners. Regular interest rates in intervals were also uncommon.

5.2.2 Rome

As much as Rome rose from city state to an empire, it took over the political power from Greece and ruthlessly controlled the economic opportunities the military control offered. The republican centuries of Rome were as much a rise to power as a struggle to allow its merchants to enter the most lucrative trade routes.[2]

Importantly, the Roman rulers copied not only the educational system and thousands of pieces of art from Greece. They also copied the most important traits of the economic system Athens and other powerful Greek cities had installed. Trade was mostly a privilege of the second class of the Roman citizens, the equestrians. They ranked below the patricians and—due to their wealth—above the normal citizens like local merchants, teachers, farmers, and the working class.

Senators were supposed to have their wealth tied to land, not to invest in trade. They should use their land, grow food, and sell it locally. This explains the ample references in historical texts to senators who retreated to their rural estates if they fell out of favor in Rome.[3] To cement this position, the Lex Claudia from 218 BC only allowed

[2] Before becoming successful in its military expansion, Rome negotiated treaties with Carthage and other places, which enabled trade with Sicily and Sardinia but restricted it further West. It took two centuries until Roman merchants could sail to most Spanish ports in 300 BC.

[3] Among many others, Plinius and Cicero repeatedly retreated to one of their villas in the hinterland of Rome. See D'Arms (1970), Mielsch (1987), Schneider (1995), Jones (2006).

senators to own ships with very limited capacity.[4] They were not meant to export their products and thus exploit their political power economically. This opened commercial opportunities for the nonaristocratic class.

5.2.3 Venice and Genoa

The Republic of Venice brought massive innovations to the world of finance. In the late 12th century, Venice struggled with Byzantium over the dominance of the Adriatic Sea. When financial sources were urgently needed to free hostages taken by Emperor Emmanuel 1st Commenos (1156–72) and money ran short, Doge Vitale II Michiel (reigning 1156–72) decided to tap into a new source of money and issued the first public loan. The government decided that the financial burden had to be shared by the Venetian people according to their wealth (Oliphant, 2012). Therefore, the public loan was anything but voluntary as all citizens had to give their share. However, the idea to not simply press the contribution from the Venetians but to promise a 5% interest rate was revolutionary and promised popular support.

Besides freeing the hostages, the public loan can be regarded as the first shipping loan—or public bond—as we know it today. No less than 120 ships could be bought by the government and put to combative use against Byzantium. Interest rates were paid for many years, but the principal was never retired because before serious fighting ensued, the plague killed most of the people on board the ships and the forces had to retreat. Involuntarily, the perpetuity was created.

A century later, the instrument of the public bond was developed even further around the "Monte Vecchio" scheme, and bondholders could trade their papers with anyone interested in a 5% return. Public bonds became a steady fixture for the Venetian Republic to finance its military forays despite numerous challenges[5] from the Catholic

[4] The Lex Claudia prohibited Senators and their sons to own merchant vessels that could carry more than 300 amphora, as such an early law on corporate governance. Political rulers should not be allowed to make policy decisions in favor of their own commercial interests.

[5] Le Goff (2004) has identified in the 12th century a returning interest of accounting which underpinned state finance and enabled trade: "The commercial revolution added rebirth of long-range commerce to the network of local and regional markets, with the spread of the monetary economy" (p. 17).

Church.[6] The scheme, in ever more sophisticated forms, lasted until the final years of the 18th century.

On the other side of the Italian peninsula, Genoa blended its wealth from maritime trade with financial savvy. Parallel to developments in Venice, in the port city the first modern-type banks developed and financed trade as well as ships.[7] Interestingly, the financing of ships was in most cases automatically combined with insurance-type deals based on the risks the asset was to be exposed.

5.3 COLONIAL TIMES

It took until the 17th century before modern corporate structures took root in Europe. It was the exploitation of colonies by the dominating European powers that demanded a new kind of organization. Much like privateers, the often brutal exploitation of colonies especially in Asia was put into private hands and beatified with a governmental shield. These massive corporate empires that ensued and traded globally had to be underpinned by a sophisticated financial structure that allowed them to rule for centuries.

With most of the new trading behemoths organized as joint-stock companies, equity was raised from shareholders and debt from banks and public bondholders. However, anyone involved needed a considerable appetite for risk, as ships that sailed off to Asia were only to be seen again months, or even years, later. Many of them never returned. Investors developed more than an intuitive sense of risk calculation and the probability of returns. One might ask if maritime discoveries and exploitation led to the development of modern finance or vice versa.[8]

Again, financial innovation grew out of the shortage of financial resources. England under Queen Elizabeth I (1533−1602) was a banker's nightmare. The government was continuously short of money, banks on the continent were asking premium interest rates when increasingly in doubt if they would ever be repaid. A financial market or even a financial

[6] Le Goff (2004) argues that the regular interest payments created a new perception of time and led to a challenge of church's time with the merchant's time. He further sees this as the end of the Middle Ages and the dawn of sophisticated capitalism. Therefore, the emergence of finance is a "fall from grace."

[7] Despite these modern ship finance instruments, Stopford (2009) sees origins of ship finance only in joint-stock companies of the 16th century (p. 195).

[8] Goetzmann (2016) suggests these lines of thought (p. 307).

culture barely existed. It was unthinkable to place government bonds with the domestic market. Even trading concessions for all known trading patterns had already been given to respective guilds. However, Elizabeth proposed monopolies on trade with *unknown* lands, a rather desperate measure, as she had no way to finance any discoveries even if they promised lucrative returns for the tax coffers. After an unsuccessful attempt by John Cabot, the first company to explore these new possibilities was the Muscovy Company in 1555. Instead of discovering the Northern Sea Route, the company established new trades with Russia.

Practically a spin-off was the "Company of Cathay," which was notable not only in being partly owned by previous pirates. It was successful in collecting Venture Capital from wealthy business people and even the Queen herself. The merchant Michael Lok developed the concept and acted as initiator. He collected the fortune of 4275 pounds to finance the fleet. Like an Emission House he did not miss out on an opportunity and collected a 20% commission on the invested money.

Across the Channel in the Netherlands, the Dutch East India Company (Vereenigde Oostindische Compagnie, VOC) saw the light in 1602 with similar goals and privileges. VOC was entitled to act practically on behalf of the government, sign treaties and wage the occasional war to support its colonial ambitions. On the one hand, it laid the groundwork for a long-lasting and profitable rule over Indonesia and its trade. On the other hand, VOC issued a frequently traded stock at the newly emerging stock market in Amsterdam (Neal, 2005). Again, the promise of undiscovered wealth and the experience of the equally risky and lucrative maritime trade initiated financial innovation. Still in the early course of the 17th century, the VOC introduced limited liability for its shareholders and the equally innovative concept of a conceptually unlimited duration of its operations. The financial means were not used to finance single ships but rather newly formed corporations, whose single aim it was to send merchant vessels around the world to transport cargo. The finance of ships and their cargo is still inseparable. However, we already see the emergence of dedicated financial tools for the shipping industry with its specific risk profile.

A somewhat less positive view is expressed by Goetzmann (2016): "British and Dutch taxpayers ultimately paid for navies to defend colonial empires that began as trading companies" (p. 305). On the one hand, this is poignant but only half true as merchants trading vessels globally had to protect themselves. On the other hand, it is an equally depressing truth that capitalism in its early stages did conquer its own trading arena with very little mercy—and many privately financed warships. The wealth the British East India Company and the VOC eventually created for both countries and specifically their shareholders relied on strictly enforced monopolistic trades. In the course of the exploitation of these monopolistic trades, the modern corporation took its infant steps. And like some 21st century start-ups, these new corporations rose to power that rivaled the financial power and influence of other countries.

Once the structures were in place, the worst was still to come. The modern colonial corporations of the 18th century brought the European commercial expansion to the transatlantic trade. In other words, the slave trade was conducted by private companies with governmental privilege and commercial ruthlessness and precision. Major beneficiaries were the Spanish and the British crown among other European rulers. The parastatal companies mounted under the umbrella of the legalized human trafficking trading outposts and factories in the New World which served as embryonic colonies. The triangular trade between Europe, Africa, and the Americas with industrial goods, slaves, and agricultural commodities, respectively, as freight was established as the most infamous trading pattern.

Financially, the 18th century sent the infant industry through a rollercoaster. In 1720 the equity bubble burst amid exuberant speculation triggered by the first joint-stock companies that were publicly traded. After this shock, public equity receded and bonds became more popular for another century. A few exceptions were the East Indian Companies, though most other trade relied on classical means of finance without ample access to public money.

5.4 INDUSTRIALIZATION

The age of industrialization changed the production and consumption patterns of the western world and strengthened global trade. Steam engines, metal ships, and the need to transport significantly increasing amounts of coal, grain, and passengers put a high demand on shipping. Most importantly, industrialization eventually divided trade from transport—both became independent economic activities. Transport became a commodity that asked for specialized companies that provided ships and offered them or parts thereof for single or multiple voyages. Steamers also made worldwide travel possible, while transatlantic voyages moved from an escape route for emigrants to the New World in the mid-1800s to an important commercial offering. Two basic types of shipping companies emerged from the middle of the 19th century with different approaches to finance their assets.

Firstly, it was the family owned shipping company with a few sailing or steamships, which often operated in the tramp trade. Dominating the first decades of this commercial shipping era, British shipping companies were involved in the majority of international trade relations—connecting Europe with the colonial hinterland based on solid protectionist policies of the empire—while local trades helped to support companies all around the European coastline. The latter companies were often involved in ancillary businesses like shipbuilding and trade but focused on sea transport. Building and destroying small fortunes in a few years, they relied on financing ships to a large extent on their own money and the injection of funds by close business partners. Loans from banks and other sources played a minor role and proved expensive: equity dominated and required appropriate public company structures.

In Germany the "Parten" company became a unique form of maritime partnership. A small group of coinvestors joined to cofinance a vessel and shared in its success or failure. The model has been known in variations since the 13th century[9] and provided the commercial backbone of the Hanse. It flourished especially for the Baltic and North Sea trades.[10] It remained the model of choice to finance merchant vessels in Germany throughout the 19th century.

It is important to note that maritime transport at this time was still not a business in itself; it remained an ancillary activity for the trade of any goods. Forming a small group of individuals or companies that built or bought a ship was a convenient way to spread the associated risk. Bank finance and other forms of financial engineering were not available, and thus the group had to put up all monies needed to buy, equip, and man a merchant vessel on their own. They also had to possess sufficient expertise in actual shipping matters. The largest shareholder acted most often as ship manager. It was not uncommon that the master was also shareholder. He also often represented the cargo interests and was in charge of negotiating and concluding the sale of the cargo at the port of destination. Also,

[9] Hamburg Admirality law from 1270 and 1301 defined it strictly as a single-ship company.

[10] Geffken (1985) hints that until the 18th century the crew enjoyed some cooperative rights on the ship without contributing financial means.

the shipyard frequently owned at least a share which secured the newbuilding contract and future cash flows. A modernized form of Partenreederei survived until 2013,[11] though only on a comparatively small scale.

In this simple form of ship-owning, each individual stakeholder is fully participating in the results of the venture according to his share in the company. The downside of this type of ship-ownership included the high capital requirements of the individual participant and that each shareholder ("*Partenreeder*") was subject to unlimited liability, albeit only for the quota corresponding to his share of the total.

Secondly, the need for larger, technically more complicated and a higher number of ships supported first publically financed shipping companies. Steamships, the booming emigration from Europe to the United States and growing US trade in general, led to a higher demand for ships. A first wave of public companies issued stocks from the middle of the century.[12] Especially after 1871, a number of liner companies issued stocks and financed their ambitious newbuilding programs. Investors were no longer shareholders of a vessel but of a company.[13]

The 19th century brought a paradigm shift into ship-owning, which also altered ship finance. Financial and technical requirements for ships increased ever more. While at first merchants, who also owned ships, moved into corporate structures and incorporated the ships onto their balance sheets, ever more merchants ceased to be interested in the transport function as an integral part of their business. The crucial nudge maybe came from the wave of emigrants. Offering passages became a business model in itself. More shipping companies moved to become entirely focused on the transport of people and wares.

As early as the 1830s, mortgages became a staple in financing ships for the increasing demands of local and international trade, at least in the

[11] With the changes to the Handelsgesetzbuch that came into force on April 25, 2013, the incorporation of a Partenreederei has ceased to exist. Those that had been incorporated before can continue on the basis of a grandfather clause.

[12] For example, Hapag started as a public company in 1847, Norddeutscher Lloyd in 1857.

[13] Some of these shipping companies managed to receive the first loans with a mortgage from commercial banks in Hamburg. Not accidentally, it was Hamburg merchants who founded Commerzbank, which became one of the early supporters of shipping companies.

leading maritime nation, the United Kingdom.[14] The rapid succession of newbuilding projects for steamships starting in the middle of the 19th century needed financial support in equity and debt to levels unknown before. In the United Kingdom, the vehicle of choice became the "sixty-fourth," whereby the ownership of the vessel was divided in 64 equal shares. Each share could be mortgaged individually. Ships (and all 64 shares of them) could be owned by individuals, partnerships, or joint-stock companies. The overwhelming majority was owned by individuals, and the mortgages were meant to bridge short-term needs in working capital. Debt was not used to finance newbuildings.

5.5 THE 20TH CENTURY

The United Kingdom and Germany competed for the largest vessels in the first years of the 20th century. The development came to an abrupt standstill through World War I. The German fleet was lost or vanished in reparations. In Germany a political debate ensued as to how the fleet could be rebuilt. An important role in these debates played the idea of a state-backed bank to finance a new fleet. Ship-owners refused the idea of this kind of government intervention and the idea was discarded. However, starting with "Schiffsbeleihungsbank Aktiengesellschaft," specialized institutes came into business with more or less government support. In particular, these shipping banks received the privilege to issue mortgage backed bonds to refinance themselves at very favorable terms on the market.

World War II did wreak havoc with the world merchant fleet. Thousands of ships were lost, trade patterns were entirely redefined to fit the war efforts, and shipping companies needed to restart. Most influential on maritime trade proved the massive newbuilding program of the so-called Liberty Ships in the United States. They became an important building block for the resuming world trade.

The first postwar decade is described as one of relative financial innocence (Stokes, 1997). Liberty Ships and T2 tankers were abundant and cheap to come by so that many traditional shipping families saw no need to engage with bank lending at all. The Korean War initially drove up

[14] Relatively early on, shipping banks offering debt finance were also established in the Netherlands. Eerste Nederlandse Scheepsverband Maatschappij is just one example of a bank mostly dedicated to ship finance.

freight rates to substantial levels. Once newly built tankers were needed, no more than 50% was to be borrowed with the security of long-term charters from the oil majors. A gravitational shift occurred in the mid-1950s, when the British Pound was restricted in its convertibility. The dollar became the currency of choice for the entire maritime industry, and in the tailwind of this move American banks became the leading lenders of the trade. First National (Citibank), Hambros, and Chase Manhattan Bank were the leading banks for ship finance.

The rapidly increasing demand for transport triggered by the rebuilding efforts after World War II in general and oil transportation specifically bore a new breed of ship-owner: the industrial shipper. Like traders and merchants in previous centuries, industrial conglomerates discovered that in order to thrive they need to transport their commodities with little friction around the world. Oil majors, steel companies, and grain traders entered shipping typically on two legs. They both took control of their own fleet and chartered an additional fleet in. While shipping became part of an industrial operation, the companies could take advantage of financial knowledge and favorable terms. Part of this movement was an expansion of charter-backed financial deals for those ships that should not appear as a heavyweight on the balance sheets.[15]

Again, Germany had to rebuild its fleet from scratch after 1945. An artificially undervalued German Mark helped to boost exports as a central instrument of its economic policy. It also made transport by foreign carriers excessively expensive. Building a German fleet became a matter of state for the emerging export nation. A variation of tax advantages helped to pave the way for outside investors into shipping,[16] eventually leading through several reincarnations into the "KG System."

Stokes (1997) defines 1962 as the crucial year, when the freight markets recovered and lenders were attracted to the maritime world to finance ships in larger numbers than ever before. Ship sizes increased rapidly,[17] and ordering a ship became more of a financial operation than a technical one. What had been ever since the industrial revolution started a rather self-reliant industry proved to have a significant appetite for outside capital in order to pursue its expansion path. It was in this context that banks no

[15] Stopford (2009) traces charter-backed finance back to the 1920s in Norway.

[16] As early as 1957, intermediaries like the investment broker Wolfgang Essen channeled tax shielded capital into newbuilding projects from private investors.

[17] The upper size limit for tankers tripled from 40,000 to 120,000 dwt in just a decade.

longer just provided a service in the form of money, but they rather helped to structure deals. They became close partners of shipyards for a bundled offer to the ship-owner: ships could be ordered together with the credit needed. It is not far-fetched to see the nucleus of the most severe shipping crisis of the 1980s in this new partnership. Banks fed money into the relation between owner and shipyard that gradually reduced a most important ingredient: risk for the ship-owner. A vicious circle started that can again be observed in almost identical form in the early 2000s. Bank finance was comparatively cheap, which led to larger-than-needed newbuilding programs. In the meantime, shipyards built ever greater capacities, which could not easily be reduced. To make matters worse, in the 1970s several governments discovered shipbuilding as an interesting employment factor and handed out guarantees, which reduced the risk factor even further and triggered ever more orders.[18] The whole spiral came spectacularly down in the overcapacities of the 1980s. It proved fatal that shipbuilding was so labor-intensive and thus received such outsized government interest, support, and subsidies.[19] Stopford (2009) makes a point in saying: "Historically the shipping industry has often suffered from too much finance" (p. 194).

An illustrative example is Japan Development Bank, which not only handed out credit on generous terms; it often did not require any equity for newbuilding orders from the shipping companies. Over several years, the Japanese fleet thus expanded by 17% per year or even more. Not enough to keep the national maritime economy booming, the scheme was extended to foreign investors. State-backed credits were used as a marketing tool to attract newbuilding orders. A quadrangular relationship enfolded: Favorable loans were handed to—often Hong Kong based—owners, who ordered vessels from Japanese yards. Subsequently, Japanese shipping lines chartered these vessels long-term.

While Japanese state-backed banks provided a dangerous mix of an ambitious policy through cheap money, competing shipping clusters did not stand still. Norway decided to top up commercial loans[20] with

[18] In the mid-1970s, Japan held over 50% of the world's shipbuilding capacity, which was largely based on the large rebuilding program that started in the early 1960s with wide-ranging government support. The support was mostly directed at the shipyards, and the build-up of the Japanese fleet was more of a collateral occurrence.

[19] Around 60% of ship mortgages were estimated to be in fact government-backed loans.

[20] Well reported is the relationship with Hambros Bank, which provided 50% on a first mortgage, while A/S Laneinstituttet for Skipsbyggeriene added the cream of another 30% at very favorable terms for the borrower.

government-backed money, as long as local shipyards were kept employed. Sweden built a similar scheme and introduced on the way something that should become the standard in ship finance in the decades to come: the floating interest rate. In the tailwind of this new development, specialized ship mortgage banks were created or strengthened in several European countries such as Germany, Sweden, and Norway. These banks could refinance their strong capital requirements through notes and handing out particularly long-running loans to yards and ship-owners.

In total, the 1960s saw the emergence of the dedicated ship finance bank in Europe. Helping European banks were drastic measures by the US administration under the Kennedy administration to limit capital outflows. These measures restricted lending to non-US owners and shifted large parts of the ship financing business back to London.

The largest political crisis in the Middle East helped to boost shipping and ship finance further. The closure of the Suez Canal increased immediately the demand for shipping by ton-mile and led more banks into the lending market. In this exuberant time, commercial banks abandoned the classical limit of 50% lending on the value of a vessel. Even without backing from Export Credit Banks, commercial banks offered at least 80% of the value as a loan on the first mortgage. In the following years, this increased further, sometimes reaching above 100%. In tandem with the increasing risk profile of shipping loans, banks counterintuitively charged ever smaller margins. From 2% in the 1950s, margins dropped due to competitive pressure to as low as 0.5% in the 1970s.[21] This practice left little cushion to carry loans through difficult markets. With more and more banks entering the seemingly lucrative market, the learning curve was steep, as described by Stokes (1997): "Ship loan documentation was alarmingly poor" (p. 23).

Naturally, in most leading shipping nations the focus of ship financing was on the shipyards, and as a strategic choice banks supported the newbuilding market. For secondhand ships it was significantly harder to find banking support, except in Greece. A multitude of ship-owners was thriving on secondhand ships, and only a select number of local and foreign banks catered for this niche. Secure fixtures and collateral from the ship or the fleet were used as security, a scheme that translated as a model

[21] One of the reasons that proper pricing of risk was neglected may be the emergence of syndicated loans, which gave the wrong impression of diversifying the risk away.

well into the 2000s, when long-term charters became the staple in the container market.

Looking back at the period until 1973, astonishing parallels to the final days of the boom in 2008 spring to mind: Banks lent at very small margins, minimal equity was demanded, and financing was often secured months or even years *after* contracting. As a result, the ship finance market was severely affected by the oil price shock in 1973 and thereafter. Freight rates for tankers dropped by 80% and more following a decline in oil demand. Many tankers were left unemployed. Building orders were changed and, subsequently, pressure rippled through the tanker and bulker market. However, the size of the ship finance schemes had grown to such proportions that bankruptcies of ship-owners would have triggered major banks to fail and some governments were afraid of a financial crash. Norway led the way, and Parliament guaranteed shipping loans.[22] Instead of letting the market play out, numerous ship-owners were saved from certain bankruptcy. As a result, a boom that was created to help shipyards turned sour and threatened the banking system, equally in 1973 and 2008. On both occasions, the ship-owners were supported, not because of themselves but because of significant third parties, either banks or shipyards.

5.6 CORPORATE FINANCE

The origins of corporate finance in shipping are usually traced back to joint-stock companies in the second half of the 19th century, when the United Kingdom used this as a vehicle to raise enough finance to build up a steamer fleet. Stopford (2009) pinpoints the combination with the Limited Liability Act of 1862 as the starting point for small investors to partner with shipping companies (p. 195). Surprisingly, corporatization did not drive debt financing until the 1960s. Shipping in the United Kingdom and equally in Greek controlled entities remained stubbornly equity financed, as Stopford (2009) notes: "Ship-owners stuck firmly to the policy of financing investment from accumulated depreciation reserves" (p. 196). Still throughout the 1960s, the gearing rate for the British and Greek fleets did not go higher than a modest 16%—indeed a

[22] The Norwegian Guarantee Institute that was created for this purpose wrote off about one-sixth of the shipping loans from Norwegian banks.

very low level compared to subsequent levels of leverage in the industry (Drobetz, Gounopoulos, Merikas, & Schröder, 2013).

The advent of container shipping in the 1970s saw a new player on the ship-owner side, the liner company. Corporate funding became a new ingredient to the ship finance market. In the first three decades after World War II, ship finance had remained mostly project finance and was built on the single purpose company. Beyond classical relationship banking a new breed of bankers were in demand to support corporate structures and help to build bridges to public financing. Once more, ship finance moved on and set up shop in Hong Kong—partly triggered by a favorable tax environment—where European and US banks as well as Asian banks financed the reemergence of a Chinese fleet. From today's perspective, the success of the Asian dollar market at the time appears surprising: floating rates moved up to 20% and meandered for extended periods of time around 15%. However, Hong Kong ship-owners were able to service their high gearing even at that interest level—at least until the crisis of the 1980s struck.[23]

While container shipping opened an entirely new segment of shipping and ship finance, the tanker and bulker sectors went into the deepest crisis after World War II: the 1980s are the lost decade of shipping, when the industry had to recover from a structural overcapacity. The global shipping community was engulfed in a fundamental crisis that hit the finance sector deeply. Numerous banks left shipping and added to the pro-cyclical movement. Banks and ship-owners spent considerable effort throughout the 1980s to escape the downturn unscathed. A common instrument became the conversion from outstanding debt into any form to equity. Another important lesson came from the government side. Neither Greece[24] nor Ireland[25] stepped in to save some of their carriers—to the surprise of bankers and management alike. In fact, shipping companies did not provide enough jobs for governments to be motivated to spend

[23] Several family owned shipping companies in Hong Kong created public outfits (Orient Overseas, Wah Kwong) with the help of banks. Shipping banks learned a recurring lesson that company strategies that mixed public and private interests were difficult to align in times of crisis.

[24] Hellenic Lines—at the time the fifth largest privately held shipping company in the world—filed for Chapter 11 in December 1983. Its total debt of about $300 million was mainly owed to suppliers who had leased containers to Hellenic (Gilpin, 1983).

[25] Irish Shipping Ltd. was liquidated in 1984 despite the important role it had played for the nation in Word War II.

taxpayer money. It proved a misconception that the support for ship-builders would spill over into the entire shipping industry.

A similar surprise for many stakeholders was the dramatic collapse of Sanko in 1985. The bulk shipping company with more than $4 billion in liabilities put several Japanese trading houses and banks in jeopardy. A debt-to-equity swap and generous tax exemptions let the company refloat. Then, 27 years later, the company filed again for bankruptcy, owing more the $2 billion and failing not only on their debt obligations, but also on numerous long-term charters.

A fatal miscalculation by investment bankers proved to be a prominent Initial Public Offering (IPO) in 1983: McLean Industries, founded by the very inventor of container ships, was raising $120 million for a newbuilding program. What is interesting in this case is not so much the speed of failure in 1986, it is rather the fact that the excessively high gearing structure was not sustainable when freight rates and load factors disappointed. The initiator, investors, banks, and other stakeholders had underestimated the risk of volatile markets. As Stokes (1997) puts it: "But it is fair to say that the shipping industry, largely because of excessive availability of debt financing and a widespread lack of rigor in its investment analysis procedures, fell victim to this dangerous variety of wishful thinking on a spectacular basis" (p. 58).

5.6.1 The Age of IPOs

The shipping crisis of the 1980s had a profound effect on ship finance. After the withdrawal of most banks from ship finance, a consensus ensued that a more solid equity base was needed. However, as few ship-owners could provide enough equity for the heavy capital requirements, the leitmotiv of the 1990s and 2000s was the search for equity outside the circle of family and friends.

The familiar baseline since the late 1980s is the abundance of credit for shipping ventures. With every upturn of the shipping cycle, enough banks entered the ship finance market to instill a competitive drive to margins much lower than the risk profile of any shipping segment should allow for. Equally, state-backed funding from Export Credit Agencies tended to fill the gaps in any downturn, especially after 2008.[26]

[26] The share of ECA funding in newbuilding meandered around 7% during the booming shipping years pre-2008, but jumped to almost 25% in 2015 (Marine Money 33, 01/2017).

The first wave of public money was gathered on two fronts in New York. A number of high-profile IPOs raised the visibility of shipping at the stock exchanges. In parallel, shipping companies tested the bond market. While at least some shipping companies sustained their listing at the stock exchanges despite heavy volatility, the maritime industry left a less than favorable impression on the bond markets, though initially a number of high-yield bonds did perform (e.g., Teekay, Eletson, Gearbulk, and Stena AB).

However, later in the decade the tide turned: The shipping industry provided the "worst single industry performance since the Great Depression" as some observer quipped. In the later 1990s, 38% of outstanding shipping bonds had defaulted, compared to an industry average of only 1.28%. With highly speculative grades and coupons usually between 8% and 13%, investors had to write off $2.5 billion of the roughly $6 billion invested.[27]

The first wave of IPOs in the late 1980s did grind to a quick halt and only resumed some five years later. Again, a larger sample of mostly spin-offs from family owned outfits made it public. None of these IPO waves proved quantitatively of qualitatively enough for the investment community to view ships as an alternative asset class. Although some investment banks set their research departments to work, shipping stocks did not manage to occupy a visible niche on Wall Street for long. From the perspective of shareholder transparency and agency problems between shareholders and managers, the continuous dealings between privately and publicly held entities from the same corporate backgrounds were certainly unhelpful.[28]

The second wave of IPOs, led by Smedvig Tankers in July of 1993, used the short window of an optimistic market with the goal to tap into

[27] Some of the shipping companies that defaulted on their bonds in this period were Cenargo International, Pacific & Atlantic, TBS Shipping, Enterprises Shipholding, Ermis Maritime, Amer Reefer, Alpha Shipping, Millenium Seacarriers, Panoceanic Bulk Carriers, Pagasus Shipping, Golden Ocean Group, Navigator Gas Transport (2x), Global Ocean Carriers and Equimar Shipholding. Kavussanos and Tsoudnikis (2014) provide a comprehensive study on shipping bonds' performance. The performance of shipping IPOs is studied in Merikas, Gounopulas, and Nounis (2009).

[28] Financial journalist Jim Cramer came forward with harsh criticism on CNBC after observing the performance of Baltic Trading in the wake of its 2010 IPO: "These low-quality companies never should have come public with such complex ownership structures that don't pass the smell test—and you shouldn't own them. Oh, and Wall Street, clean up your act with these shipping IPOs. We deserve better."

the parallel debt markets. The third wave came on the back of exuberant markets that remained bullish for a very long time and carried numerous shipping companies to the exchanges between 2004 and 2008. The fourth wave, led by Baltic Trading in 2010, was considered a brief spate of mostly spin-offs and attempts to test the markets after the financial collapse in 2008. The surprising upturn of the markets could only be used by the well-prepared companies. The final large wave was almost exclusively dominated by tanker companies, as they enjoyed countercyclical positive markets. The most popular at this stage were the US MLP[29] structures, which catered in particular for the tanker market. The last major shipping IPO was the long-planned move by Hapag-Lloyd in 2016.

The most common stock markets for shipping stocks besides New York are London,[30] Oslo, Copenhagen, Singapore, and Hong Kong. Additionally, some lesser known places have been used for local companies like Taipei, Bangkok, and Jakarta.

5.6.2 Fund Structures

Limited liability was at the core of the Norwegian Kommandittselskap System (K/S), which drew relatively large amounts of capital into shipping funds in the mid-1980s. The system proved attractive as a tax shield for high-income citizens. It helped with very low soft costs to acquire mainly secondhand tonnage.

In Denmark, in the early 2000s the Det Indre Selskap (DIS) created numerous closed-end funds for shipping projects and the acquisition of tonnage. In the Netherlands, on the basis of tonnage tax, the Commanditaire Venootschap (CV) similarly created a variety of open-end or closed-end funds. What was unusual here was that the investment scheme extended to cable layers, dredgers, and offshore projects.

Probably the most successful scheme outside the stock markets to collect equity beyond friends and family has proved to be the German "KG model" or "KG system." Underpinned by tonnage tax and a secure legal environment, German owners could tap into the vast potential of

[29] Master Limited Partnerships (MLP) existed since 1987 and were originally designed for infrastructure projects. They are tax-driven structures with their entire focus on dividend yield.

[30] London lost its weight already in the late 1980s and again in 2016/17, when some of the last remaining shipping companies left the stock exchange.

investors with a large risk appetite. It became the cornerstone of the resurgence of the German merchant fleet, especially with its foray into container ships.

The acronym "KG" stands for Kommanditgesellschaft, one of the possible forms of incorporation in Germany. The "system" refers to five pillars that together formed the basis for success[31]:

1. Tonnage tax (since 1999) and previously advantageous German tax-law that made investments in ships attractive.
2. Limited liability through the combination of private and corporate structures, with the GmbH & Co. KG allowing for the tonnage tax to apply to all dividends.
3. German shipping banks with a strong preference for local customers and relationship banking with a focus on asset finance.
4. Private investors, led by the proverbial lawyers and dentists, who explored investment opportunities beyond savings accounts.
5. A shipping cluster eager to initiate a long pipeline of offers and at the same time stepping up as ship managers.

In the 1960s, a large-scale gray financial market developed, attracting intermediaries who liaised between ship-owners and potential investors.[32] Specialist syndicators ("*Emissionshäuser*") started to offer products to a wider range of investors.[33] Contrary to the majority among other leading ship-owning nations, the modern German KG system for ship investment is not primarily directed at deriving profits from asset play, but rather at generating steady cash flows from operating the assets, preferably under time charter contracts.

5.6.3 Leasing

The 20th century has built numerous models of ship finance that blended the two all-important income streams for the maritime industry: a speculative side of ship-owning and a cash-flow-driven side of freight income as well as ship management. Slowly, further specialization has been growing, as ship managers and crew managers emerged since the 1970s as service providers. On the side of finance, the bareboat charter (or demise

[31] For a detailed description of the KG model and its history, see Johns and Sturm (2015).

[32] Early movers in the new market were companies like DIVAG (1968), Conti (1970), Norddeutsche Vermögen (1975), or Hansa Treuhand (1983).

[33] Up to €3.5 billion per year were collected until 2009 according to VGF (Verband Geschlossener Fonds), when the market came to a standstill.

charter) has provided a model to separate ownership almost completely from the daily operations of a vessel.

In the 21st century, financial institutions have entered the fray of ship finance with a sole focus on the financial side of the business. Therefore, since 2008 at least, leasing has been growing its market share in ship-ownership at a rapid pace, replacing hesitant equity sources and stressed banks. Classical leasing structures allow financial institutions to focus on the financial engineering part of the maritime industry and exploiting the competitive advantage of favorable financial terms.

Classical leasing structures that promise steady, predictable, and long-term cash flows are rarified examples in the shipping industry. Some MLP structures managed to produce similar cash flows, but only very few containership leasing companies could eventually prove that steady cash flows are possible.[34]

Often leasing structures have been associated with state backing and eventually interests that reach into shipbuilding and ship supply. This appears as an echo from historical examples. In particular, the quick rise of Chinese leasing structures in ship finance since 2012 from mostly state-backed banking conglomerates seems to be targeted at least as much toward the national shipbuilding industry as the shipping industry itself.[35]

5.7 CONCLUSIONS

As can be seen from this historical overview, the shipping industry has tapped into practically all kinds of common financing sources. However, the focus of interest between owners, investors, banks, alternative finance sources, and governments has shifted between the cargo, shipbuilding, and the ships themselves. The changing focus has blurred the view on the underlying risk involved. Often, equity and debt have been offered too cheaply because side interests were involved and political goals led to the underpricing of risk. For the ship-owner this offered opportunities to build fleets and eventually overbuild markets. These conflicts of interest may also explain why the shipping industry is still somewhat underrepresented in the public capital markets and research coverage comparatively

[34] Global Ship Lease (GSL) is still struggling for a steady performance despite its close link to its founding mother CMA CGM.

[35] Chinese ship leasing models need to be seen as part of the "Made in China 2025" policy, which has the target to increase the market share in key technologies. High-tech components of ships are considered a key technology under this umbrella.

scarce. Nonmarket-driven interventions into the industry add to the already high business risks, implying that structured investments have proven difficult to market. It thus seems fair to argue that ships are not an established asset class for either private or institutional investors. As long as government intervention remains a strong component in shipping, ship finance is necessarily a high-risk undertaking, which asks for entrepreneurial risk-takers.

Despite the considerable risk and volatility in ship finance, choosing among the different methods and strategies does not fully follow common rules of corporate finance. With an overwhelming majority of shipping companies following private interests or governmental interventions, rational financial strategies are not necessarily at the forefront. However, there is a sufficiently large group of publicly traded shipping companies, where risk profiles can be derived and capital pricing models applied (Drobetz, Menzel, & Schröder, 2016; Drobetz, Schilling, & Tegtmeier, 2010). Wherever possible, it seems worth looking into financial opportunities that potentially underprice the inherent risk and allow for significant abnormal returns.

This historical overview also shows that shipping and ship finance have been considered as a special industry for centuries. Digitalization may change this view rapidly. Within the entire supply chain, shipping is moving closer together with other players. New players like Amazon, Google, and Alibaba may enter the supply chain with a more holistic view, depriving shipping of its specialness. Shipping will have to integrate its service part closer with the other parts of the logistics chain. If supply chains may be owned and integrated by larger market players, potential risk will be filtered out. These developments may pave the way for more structured financing models for ships.

The shipping industry in its modern form has thrived on the division of labor. When a “prolonged workbench” could stretch to foreign countries and continents, shipping became the backbone of world trade. Over the centuries, ship-owning has moved from an ancillary activity of the merchant to a standalone commercial activity. Various cultures have carefully included a variety of capital sources into the financing of ships. Partnerships, debt finance, and the sole focus on asset finance have been just some of the possibilities.

Importantly, ship finance has experienced massive market distortions through direct and indirect government interventions. The interests behind these interventions have occasionally been the merchant fleet itself when countries felt the need for an independent supply line. Most often, the regulatory interest was directed at local labor-intensive fields of the maritime industry in shipbuilding and supply: "The interference of governments in the financing of the shipping industry since the 1960s has perhaps been the most harmful single influence on the industry," commented Stokes (1997). Again, in 2018 supply and demand for cargo volume do not balance due to substantial interventions on behalf of the shipbuilding industry, this time in Asia.

Additionally, massive competition on the side of dedicated shipping banks led to an unrealistically low-interest environment throughout most decades since World War II and influenced supply and demand so much that a market-driven balance was too often avoided. As noted by Stokes (1997): "The effect was similar to the debility produced in a human being by persistent drug-taking."

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CHAPTER 6

Investor Sentiment, Earnings Growth, and Volatility: Strategies for Finance in International Shipping

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6.1 INTRODUCTION

Measuring and analyzing the investors' sentiment in different markets and sectors has been a long-standing research item for academics and practitioners alike. International maritime logistics and seaborne commodity transportation relate to an industry which is characterized by cyclicality, seasonality effects, business cycles of different duration, extreme volatilities in prices and rates, and "wildcard" events. Having a measure of the sentiment of the investors involved in the industry is important, as it can help formulate market expectations, assist in the fair-price valuation of assets (vessels), generate industry entry (buy) and exit (sell) signals, as well as potentially increase liquidity in terms of number of trades. This chapter investigates the total, market, and sector-specific sentiment indices in the Capesize and Panamax subsectors of the international shipping industry. The effects of investor sentiment on vessel earnings are analyzed in the dry bulk subsectors, with earnings serving as a benchmark index to represent the wealth of a sector. Empirical results indicate that market sentiment has a significant impact on the conditional mean and variance of the market earnings growth rates. Furthermore, results from the examination of the lead—lag relationship between investor sentiment, earnings, and their respective volatilities indicate that there is a bidirectional causal relationship between sentiment and earnings. The rest of the chapter is structured as follows: Section 6.2 presents the background and

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construction methodology of the sentiment index of shipping market investors; Section 6.3 investigates the effect of investor sentiment on shipping earnings and volatility, and the causal relationships between them; finally, Section 6.4 concludes the chapter.

6.2 SENTIMENT INDEX FOR SHIPPING MARKET INVESTORS

Given the lack of a common measure of investor sentiment for stock markets internationally, business and consumer confidence indices (Lemmon & Portniaguina, 2006; Schmeling, 2009), and investors' surveys (Brown & Cliff, 2004; Lee, Jiang, & Indro, 2002; Menkhoff & Rebitzky, 2008) have been employed and found to be highly adequate measures. However, their construction is based on surveys, and actual actions of consumers, businesses, and investors can differ substantially from that of their responses, which can eventually lead to biased indices. Previous studies (Baker & Wurgler, 2006; Baker, Wurgler, & Yuan, 2012) use market price-based proxies such as closed-end fund discounts, initial public offerings (IPOs) volume and first-day returns, volume turnover, equity share of new issues, dividend premium, and the volatility premium. We overcome this limitation using a shipping investor sentiment index for the dry bulk market that is based on actual market sentiment proxies and the principles set out by Papapostolou, Nomikos, Pouliasis, & Kyriakou (2014) and Papapostolou, Pouliasis, Nomikos, & Kyriakou (2016).

The proxies are classified into three categories: market expectations, valuation, and liquidity. The market expectations category includes two proxies, the net contracting (NC) and money committed (MC). The NC proxy measures the number of vessels being contracted with shipyards after accounting for vessels being scrapped, and its employment stems from the analogy that the net demand for vessels in the shipping market resembles the demand for new equity issuance in the financial markets (Baker & Wurgler, 2006, 2007; Baker et al., 2012) as the demand for IPOs is considered to be extremely sensitive to investor sentiment. Moreover, when valuations are generally high, there is a tendency for shipping investors to herd in their decision to invest in new capacity (Papapostolou, Pouliasis, & Kyriakou, 2017). Usually, high shipping earnings are associated with high secondhand vessel prices and an inflated order book, but forecast low future returns (Greenwood & Hanson, 2015). Furthermore, Greenwood & Hanson (2015) argue that overinvestment in new capacity during boom periods of the cycle is due to shipowners being overconfident and incorrectly believing that investments will continue to reap high returns.[1] Therefore, high shipping sentiment periods are characterized by high vessel orders, while cancellations and scrapping of vessels are at low levels.

The MC proxy is chosen as an analogy to broader measures of financing activity that have been previously employed in the literature as sentiment proxies. Baker & Wurgler (2000) suggest that the percentage of equity issues in the total of equity and debt issues is a measure of financing activity that can capture sentiment. In the case of shipping projects, the main and traditional source of capital is bank finance with a historical average debt-to-equity ratio of 70:30 for a straightforward project. Additionally, expansion phases in the freight rate market, i.e., high levels of sentiment, have been historically fueled by the liberal availability of debt finance for newbuildings. At the same time, as providers of credit are overconfident, there is a corresponding willingness of investors to become excessively geared. The above stem from the fact that shipping is a niche market where providers of credit dislike losing market share and as such follow their competitors. Therefore, the MC is positively related to investor sentiment.

The valuation category includes two proxies, namely the price-to-earnings (PE) and secondhand-to-newbuilding (SNB) ratios. The PE proxy has been previously employed as a measure of sentiment and has been identified as a predictor of stock returns (Campbell & Shiller, 1998; Fisher & Statman, 2006; Kurov, 2008). Usually, high investor sentiment levels are associated with high PE ratios, reflecting in that way the relative degree of overvaluation in asset prices. The calculation of the PE proxy takes into account the expected earnings to be received from operating a vessel for 1 year from the point of valuation. As such, when current vessel values are high relative to the forward-looking earnings, i.e., high PE ratio, investors anticipate vessel values to drop in the future to reflect limited earnings growth. Thus, high PE ratios are associated with low sentiment levels.

There are occasions when secondhand vessel values may surpass newbuilding ones. Newbuilding vessels have longer useful economic lives than identical secondhand vessels of certain age, which in general implies

[1] Greenwood and Hanson (2015) attribute this behavior partly to "competition neglect" by shipowners, which is caused by the time lag involved in the shipbuilding process (Kahneman, 2011).

higher capital outlays. However, during prosperous freight market conditions and high sentiment periods, investors prefer to take advantage of the prevailing market conditions immediately. As a result, they favor the purchase of secondhand vessels to avoid the time lag in the construction process of newbuildings.[2] This preference consequently creates an immediate delivery premium that may occasionally drive secondhand vessel prices above newbuilding vessel prices. The selection of SNB as a sentiment proxy is by inverse analogy to Baker & Wurgler (2004) employment of dividend premium. Dividends are generally perceived by investors as a characteristic for safety (Baker & Wurgler, 2006). When dividends are at premium, companies are more likely to pay them and less so when they are at discount (Fama & French, 2001). Therefore, companies appear to cater for prevailing sentiment for or against "safety" in their decision of dividend distributions. Similarly, SNB reflects the preference of investors for secondhand vessels and captures the immediate delivery premium, which is related to the level of optimism or pessimism regarding the current market conditions.

The last category reflects the relative liquidity in the shipping industry. The use of liquidity as a sentiment proxy follows from Baker & Stein (2004) who suggest turnover as a candidate proxy for investor sentiment. However, liquidity is an elusive notion (Amihud, 2002; Pastor & Stambaugh, 2003) which has been represented by various empirical measures in the literature.[3] Baker & Wurgler (2006, 2007) capture market liquidity by the ratio of trading volume to the number of shares listed on the New York Stock Exchange, whereas Baker et al. (2012) use the ratio of total dollar volume over a year to the total market capitalization at the end of the previous year. Shipping market liquidity is represented by the turnover ratio (TURN), which measures the activity in the sale and purchase market for secondhand vessels in terms of the total number of

[2] The building of new vessels is characterized by significant construction lags. The actual construction time, which is on average 2 years, may often be lengthened considerably by the lack of available berth capacity in shipyards or due to order backlog. For example, Kalouptsidi (2014) quantifies the impact of time-to-build on shipping investments and estimates that the average construction time almost doubled between 2001 and 2008.

[3] Proxies for liquidity, among others, include (1) turnover (Amihud & Mandelson, 1986), (2) dollar volume (Chordia, Subrahmanyam, & Anshuman, 2001), (3) share volume (Brennan & Subrahmanyam, 1995), (4) Roll-implicit spread estimator (Roll, 1984), (5) illiquidity ratio (Amihud, 2002), and (6) proportion of zero returns measure (Lesmond, Ogden, & Trzcinka, 1999).

Table 6.1 Proxies of sentiment index explained

1.	$NC_{q,t} = contr_{q,t} - scrap_{q,t}$	$contr_{q,t}$ is the number of vessels in sector q during month t being contracted with a shipyard and $scrap_{q,t}$ the number of vessels being scrapped.
2.	$MC_{q,t} = order_{q,t} \times newPx_{q,t}$	$newPx_{q,t}$ is the price of newbuilding vessels in sector q during month t.
3.	$PE_{q,t} = schPx_{q,t}/earn_{q,t}$	$schPx_{q,t}$ is the price of 5-year old secondhand vessels and $earn_{j,q,t}$ the annualized earnings (1-year time-charter rates) in sector q during month t.
4.	$SNB_{q,t} = schPx_{q,t}/newPx_{q,t}$	See above.
5.	$TURN_{q,t} = M^{-1} \sum_{p=t-M+1}^{t} sales_{q,p}/fleet_{q,p}$	$fleet_{q,p}$ is the total number of available vessels in sector q and month p, $sales_{q,p}$ the number of vessels sold and $M = 12$ months up to time t.

vessels available in the market, whereas high turnover periods are associated with high sentiment periods. Please refer to Table 6.1 for more details on the estimation of the six sentiment index proxies.

We compute the proxies for Capesize and Panamax vessels, as they are the most representative dry bulk vessel types, on a monthly basis over the period March 1997 to August 2017 with data from Clarkson Shipping Intelligence Network. All proxies are orthogonalized to the G7 monthly industrial production growth and two recession-period dummies for the G7 and Major 5 Asia countries[4] to remove the nonshipping-related sentiment part. The proxies then are de-trended using the one-sided Hodrick–Prescott filter and their cyclical component is used in the analysis. Finally, following Baker et al. (2012), we construct total, market, and sector-specific sentiment indices using the first principal component method.[5]

[4] Data provided by the Organisation for Economic Co-operation and Development (OECD).

[5] See Papapostolou et al. (2014, 2017) for more information.

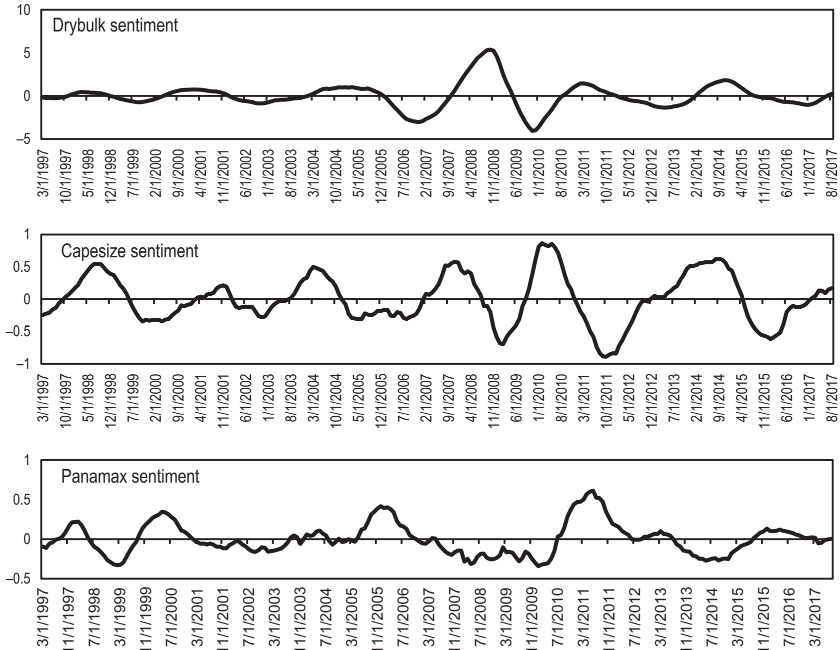

Figure 6.1 Market and sector-specific sentiment indices (12-month average).

The 12-month average market and sector-specific sentiment indices are plotted in Fig. 6.1. The sub-plots indicate that the market sentiment is smooth, thus capturing market-wide changes such as the recent financial and shipping crises. On the other hand, sector-specific sentiment indices move in a more erratic way and reflect the idiosyncratic features of each sector.

6.3 THE EFFECT OF INVESTOR SENTIMENT ON SHIPPING EARNINGS AND VOLATILITY

For the purpose of our analysis, monthly average long-run historical earnings are obtained from Clarkson's Shipping Intelligence Network. Time series of earnings are quoted in US dollars per day ($/day) and cover the period March 1997 to August 2017 (246 monthly observations; same period with the sentiment indices' data). We use two different size dry bulk carriers, namely, Capesize and Panamax (classified according to their size and capacity) as well as the weighted average earnings of all bulkers on aggregate (Capesize, Kamsarmax, Panamax, Supramax), essentially reflecting exposure to dry bulk shipping.

The components of the average vessel-type earnings (all dry bulk, Capesize and Panamax) are averages of the voyage earnings for selected routes.[6] Capesize vessels are dry bulk carriers with a cargo carrying capacity exceeding 150,000 deadweight (dwt). They normally operate along long-haul routes transporting iron ore mainly from South America and Australia to the Far East (primarily China), and coal from North America, Australia, and South Africa to the Far East and North Europe.[7] Panamax vessels have a capacity of 60,000–99,999 dwt and are used mainly to carry grains from North America, Argentina, and Australia, and coal from North America, Australia, and South Africa either to Europe or the Far East; to a lesser extent, Panamax also carry minor bulks, including fertilizers, forest, and steel products.

Note that, the employed earnings are not intended as precise figures of the earnings of specific vessels. For example, certain factors such as vessel waiting time at port or time the vessel is off-hire are not accounted for in the earnings calculations. As such, the employed sample data of earnings serve as benchmark indices that are representative of the vessel-type earnings and wealth of each sector.

6.3.1 Modeling the Conditional Mean and Volatility of Dry Bulk Earnings

Volatility is of great concern to economic agents involved in the decision-making process under uncertainty. Starting with the seminal article by Engle (1982), autoregressive conditional heteroscedasticity (ARCH) models

[6] Note that the time series of earnings are composite series which are based on earnings for a 1990s-built vessel prior to start January 1998; then a 2000-built vessel; and post start January 2009 a 2010-built bulk carrier. For more details on the earnings calculation methodology and assumptions, we refer to Clarkson's Research Services Limited, http://www.clarksons.net/archive/research/archive/SNM/SIW_SNM.pdf (Sources & Methods document).

[7] The name Capesize is attributed to the fact that this type of vessel is too large to transit the Panama canal, therefore it has to navigate around Cape Horn. Panamax is the largest permissible vessel size that can transit the Panama canal fully laden. Typical sizes are 172,000 and 74,000 dwt, for Capesize and Panamax, respectively.

have been traditionally used to describe the conditional volatility of financial time series. One of the first variations of the ARCH model, namely the generalized ARCH (GARCH)—introduced by Bollerslev (1986)—has also been the object several studies, postulating several extensions, due to its flexibility. These models have been widely used to study the fluctuations in financial time series; the model is able to capture several salient features of asset returns, such as volatility clustering, persistence, nonlinear dependence, and thick tails. This is of paramount importance since the variance structure is an indispensable parameter in asset pricing, asset allocation, and risk management decisions.

Irrespective of the interesting properties, the standard GARCH model has limitations. For example, to ensure positiveness of the conditional variance, nonnegativity constraints on the coefficients in the variance equation must be imposed. Moreover, a phenomenon often encountered is that volatility is affected by negative and positive shocks in different ways; e.g., the so-called leverage effect (Black, 1976) which occurs when changes in asset prices are negatively correlated with volatility. Therefore, in recent years, modeling the behavior of the second moments of a time series is a research area which has been developed extensively in the finance and economics literature; see, inter alia, Higgins & Bera (1992), Glosten, Jagannathan, & Runkle (1993), Zakoian (1994), and Gray (1996). For a comprehensive review and more technical details on GARCH models, the reader is referred to Poon & Granger (2003).

In the ensuing analysis, we employ Nelson's (1991) exponential GARCH (EGARCH) model with an autoregressive (AR) specification for the conditional mean of the series, i.e., earnings growth for dry bulk weighted average and the individual sectors, i.e., Capesize (cpz) and Panamax (pmx). The EGARCH framework allows for information asymmetry, different impacts of positive and negative shocks on the returns. The exponential formulation of the variance process has the advantage that the particular specification ensures that the nonnegativity constraints on the parameters of the model are not violated, as the sentiment indices could be negative. We also include in the mean and variance equations an extra term, which is the lagged sentiment index, $Sent_{t-1}$. The full EGARCH-X model can be written as follows:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 Sent_{t-1} + \varepsilon_t \qquad (6.1)$$

$$\varepsilon_t / \Omega \sim iid(0, \sigma_t^2)$$

$$\sigma_t^2 = \exp\left(\beta_0 + \beta_1 \frac{|\varepsilon_{t-1}|}{\sigma_{t-1}} + \beta_2 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta_3 ln\sigma_{t-1}^2 + \beta_4 Sent_{t-1}\right) \quad (6.2)$$

In the above augmented EGARCH specification (EGARCH-X), y_t represents the dry bulk, Capesize and Panamax earnings (log-changes). Further, σ_t^2 is the conditional variance of earnings' growth rate and ε_t are normally distributed innovations. The β_1 coefficient measures the asymmetric impact of shocks with a different magnitude on earnings volatility, while the β_2 coefficient reflects the asymmetric impact of shocks with different signs on volatility. Also, β_3 measures the sensitivity of variance to its past and β_4, the response of earnings' growth levels to investor sentiment.

Table 6.2 exhibits the estimation results, values of the maximized log-likelihood (LL) function and diagnostic tests of the volatility models that link the dynamics of earnings growth and volatility to investor sentiment. Parameters are estimated using numerical optimization methods and maximum likelihood.[8] We estimate three sets of conditional volatility models; without sentiment index in the mean and conditional variance equations (w/o Senti); with the market sentiment index (w total Senti); and with the sector-specific sentiment indices (w sector Senti) in the respective equations; note that total and dry coincide and are interchangeable terms in this case. For a more parsimonious representation, the lag order for the AR term in the mean equation and the orders of ARCH, GARCH, and asymmetry terms are all fixed to one. Still, diagnostic test results indicate that all models are well specified with no signs of either autocorrelation or ARCH effects in the standardized residuals of each model.

The significance of the coefficient of lagged dependent variable (AR term) in all models reveals significant and positive first-order autocorrelation in monthly percentage changes in the shipping earnings. The positive autocorrelation implies that positive (negative) growth rates are likely to be followed by positive (negative) rates; this is indicative of the persistence of cyclical events in the shipping industry. Turning next to the ARCH and GARCH coefficients, we can see that these are all significant, at conventional significance levels. Moreover, the asymmetry term β_2 is statistically different than zero, i.e., model estimates corroborate that the volatility

[8] Having specified the model of Eqs. (6.1) and (6.2), the log-likelihood function can be written as $LL = \sum_t ln\left\{\frac{1}{2\pi\sigma_t} e^{-\frac{1}{2}\frac{\varepsilon_t^2}{\sigma_t^2}}\right\}$.

Table 6.2 Conditional volatility estimates for dry, Capesize, and Panamax earnings with and without sentiment

	EGARCH w/o Senti			EGARCH-X w total Senti			EGARCH-X w sector Senti	
	Dry	cpz	pmx	Dry	cpz	pmx	cpz	pmx
Mean equation								
α_0	− 0.0039	0.0076	0.0000	− 0.0016	0.0016	− 0.0051	0.0052	− 0.0005
	(0.008)	(0.013)	(0.012)	(0.008)	(0.013)	(0.012)	(0.013)	(0.012)
α_1	0.3505***	0.1959***	0.1024**	0.2560***	0.1414**	0.0676*	0.2053***	0.0966*
	(0.090)	(0.073)	(0.048)	(0.088)	(0.066)	(0.039)	(0.078)	(0.056)
α_2	–	–	–	− 0.0165**	− 0.0461***	− 0.0257***	− 0.0435	− 0.0328
	–	–	–	(0.007)	(0.012)	(0.009)	(0.046)	(0.056)
Variance equation								
β_0	− 0.4588***	− 0.2825***	− 0.9192***	− 0.3863***	− 0.2216***	− 0.7555**	− 0.2724***	− 0.7757***
	(0.104)	(0.056)	(0.293)	(0.120)	(0.054)	(0.325)	(0.060)	(0.300)
β_1	0.3152***	0.2678***	0.2551*	0.2371***	0.2008***	0.1587	0.2612***	0.1828
	(0.069)	(0.070)	(0.147)	(0.072)	(0.060)	(0.128)	(0.073)	(0.121)
β_2	− 0.0509	− 0.0928**	− 0.3260***	− 0.0544	− 0.0847	− 0.1931**	− 0.0902*	− 0.3125***
	(0.049)	(0.046)	(0.072)	(0.060)	(0.053)	(0.090)	(0.051)	(0.071)
β_3	0.9397***	0.9630***	0.7876***	0.9458***	0.9684***	0.8162***	0.9647***	0.8143***
	(0.018)	(0.011)	(0.063)	(0.020)	(0.011)	(0.073)	(0.011)	(0.069)
β_4	–	–	–	0.0345***	0.0313***	0.0667***	0.0116	0.1260
	–	–	–	(0.007)	(0.010)	(0.017)	(0.032)	(0.164)
Diagnostics								
$\overline{R}^2$	0.098	0.006	0.008	0.125	0.022	0.050	0.010	0.010
LL	152.11	− 25.70	73.73	158.07	− 20.10	80.28	− 25.40	76.82
LB(1)	[0.847]	[0.661]	[0.785]	[0.999]	[0.752]	[0.987]	[0.711]	[0.868]
LB(6)	[0.332]	[0.568]	[0.900]	[0.121]	[0.145]	[0.611]	[0.559]	[0.831]
ARCH(1)	[0.876]	[0.274]	[0.411]	[0.774]	[0.624]	[0.302]	[0.265]	[0.384]
ARCH(6)	[0.971]	[0.925]	[0.623]	[0.939]	[0.995]	[0.806]	[0.924]	[0.629]

The coefficient values of the EGARCH and EGARCH-X models are reported here (see Eqs. 6.1 and 6.2). LB(*k*) is the Ljung and Box (1978) test for autocorrelation of lag order *k*. ARCH(*k*) is the Engle (1982) test for ARCH of lag order *k*. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

spillover function is asymmetric. The presence of asymmetry is consistent with the concept of the leverage effect (Black, 1976), i.e., negative shocks have greater impact on volatility rather than positive ones of the same magnitude, i.e., market participants are more prone to negative news. This is observed mainly for the Capesize and Panamax subsectors, while for the weighted average dry bulk earnings, this effect is not significant, although consistent in terms of sign. That is, overall, volatility of earnings is more aggravated through the risk factors that negatively affect markets. Moreover, significance and high values (above 0.78) of lagged variance coefficient, β_3, in the variance equation of all models indicate a relatively high degree of persistence in the volatility of earnings growth rates. This implies that shocks to the market tend to die out slowly and volatilities seem to show long memory. This is consistent across earnings for all the considered markets, i.e., dry bulk, Capesize, and Panamax.

Next, coefficients α_2 in the mean equation show that total sentiment is statistically significant and a contrarian indicator of future earnings, for individual subsectors or on aggregate dry bulk earnings. For example, a decrease in the total sentiment by 1 SD is associated with 1.65%/month higher earnings; the corresponding responses of Capesize and Panamax are even higher, standing at 4.61% and 2.57%, respectively. Furthermore, it appears that market sentiment overshadows sector-specific sentiment (which is insignificant) and that monthly earnings are mainly affected by market sentiment. This is consistent with the findings of Papapostolou et al. (2014) for the case of vessel price returns. Therefore, our results confirm that as market sentiment appears to be significant across all sectors, implying cross-sector sentiment contagion.

Furthermore, total sentiment in the variance equation shows statistically significant results. Volatility is higher (lower) when sentiment is positive (negative). Broadly, from coefficients β_4 in Table 6.2, we infer that total sentiment has a positive impact on earnings' volatility which implies that high optimism (pessimism)—which is further associated with lower (higher) future expected earnings as a contrarian indicator—leads to upward (downward) revisions in the conditional variance. Finally, the sector sentiment results are not significant (consistent with coefficients α_2 in the mean equation), implying that only the total sentiment has the capacity to capture volatility persistence and clustering.

Overall, we find that the total market sentiment index has a significant impact on the conditional mean and variance of the market earning

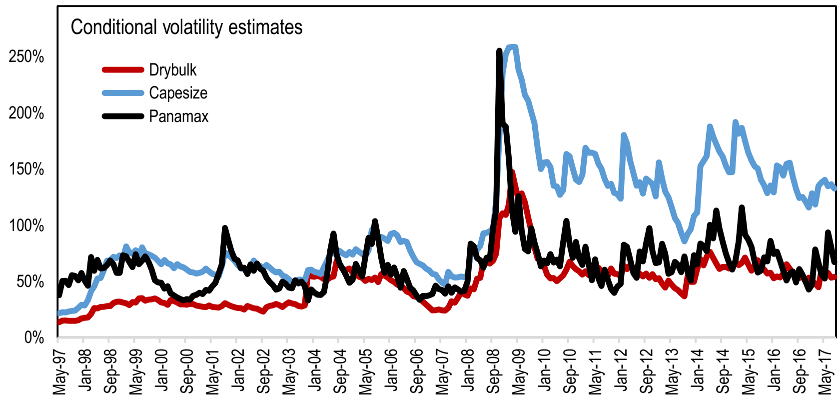

Figure 6.2 Conditional volatility of market and sector-specific earnings.

growth rates. Note also the increase in the adjusted *R* squared figures ($\overline{R}^2$), in the range of 160 (cpz) to 420 (pmx) basis points as well as the improvement in the log-likelihood values.[9]

In order to highlight the changes in the second moments of shipping earnings over time and compare the degree of fluctuations across vessel sizes, we plot in Fig. 6.2 the annualized conditional volatility processes for dry bulk, Capesize and Panamax growth rates, as estimated by the EGARCH model, augmented by the (lagged) total sentiment. The time evolution of the series indicates that earnings volatility for each type of vessel has decreased significantly over the last 9 years following the peak of the 2008 financial crisis. For instance, in the Capesize (Panamax) market, the annualized volatility of earnings throughout the period September 2008 to August 2009 averaged at 212% (132%) compared to 129% (59%) over the period September 2016 to August 2017. Total dry bulk earnings volatility figures stand lower at 112% and 53% as a result of diversification effects, since the earnings are the weighted average of all dry bulk carriers. However, comparing the figures prior to and post financial crisis, volatility has stabilized at relatively higher levels than their historic average. For example, for the Capesize (Panamax) market, the

[9] The effect of parameter restrictions can be formally assessed via the standard likelihood ratio test statistic-2 ($LL_R - LL_U$), where LL_R (LL_U) is the log-likelihood of the restricted (unrestricted) parameterization. The tests favor the inclusion of the total sentiment in the mean and variance equations at 1% level compared to the EGARCH w/o Senti model. On the other hand, inclusion of sector-specific sentiment leads to marginally higher, yet insignificant (at 1% level) log-likelihood values.

annualized volatility of earnings from 1997 to 2007 averaged at 63% (54%) compared to 142% (66%) over the period 2010–17. Total dry bulk earnings volatility figures stand at 35% and 58%, for 1997–2007 and 2010–17, respectively.

6.3.2 The Sentiment Impact Examination Using Causality and Impulse Responses

Next, to capture the AR behavior of the investor sentiment, we employ the vector autoregressive analysis (VAR framework) to examine the lead–lag relationship between investor sentiment, earnings, and their respective volatilities. At time t, consider the vector:

$$Z_t = \left[\, y_t, \quad Senti_t, \quad \sigma_t, \quad \sigma_{Senti,t} \,\right]' \tag{6.3}$$

where y_t represents the dry, Capesize and Panamax earnings (log-changes) and $Sent_t$, the total market sentiment index. Guided by our previous results, we do not present the results of the sector-specific sentiment indices as their impact on earnings growth rates and volatilities was insignificant. Further, σ_t is the conditional volatility of earnings' growth rate (EGARCH model w/o sentiment). $\sigma_{Senti,t}$ is the conditional volatility of investor sentiment estimated by applying the EGARCH model of Eqs. (6.1) and (6.2); after setting $\alpha_2 = \beta_4 = 0$ (results are available from the authors upon request). Let ε_t^j denote the shocks to the system, A a matrix of coefficients, and l the lag order. Then, a four-variate VAR model can be constructed in the following way:

$$Z_t = a + \sum_{i=1}^{l} A_i Z_{t-i} + \begin{bmatrix} \varepsilon_t^{Earnings} \\ \varepsilon_t^{Sentiment} \\ \varepsilon_t^{Earnings\,Volatility} \\ \varepsilon_t^{Sentiment\,Volatility} \end{bmatrix} \tag{6.4}$$

The above multivariate representation essentially provides a rich framework for valid inference regarding the causal linkages between sentiment and earnings. A time series, say sentiment, is said to Granger cause another time series, say earnings, if the present values of earnings can be predicted more accurately by using past values of sentiment than by not doing so, considering also other relevant information including past values of earnings (Granger, 1969). If both earnings and sentiment Granger cause each other then there is a two-way feedback relationship between the two variables. Therefore, the VAR model of Eq. (6.4) can determine whether

Table 6.3 Granger causality tests

	Dry	cpz	pmx
$y_t \rightarrow Senti_t$	11.05***	7.521***	6.551***
$y_t \rightarrow \sigma_t$	7.155***	19.23***	96.52***
$y_t \rightarrow \sigma_{Senti,t}$	2.298**	2.578**	1.171
$Senti_t \rightarrow y_t$	7.257***	3.192***	6.046***
$Senti_t \rightarrow \sigma_t$	2.838**	2.458**	5.291***
$Senti_t \rightarrow \sigma_{Senti,t}$	1.187	1.187	1.187
$\sigma_t \rightarrow y_t$	2.682**	1.255	4.105***
$\sigma_t \rightarrow Senti_t$	5.917***	3.734***	9.135***
$\sigma_t \rightarrow \sigma_{Senti,t}$	8.221***	4.757***	5.412***
$\sigma_{Senti,t} \rightarrow y_t$	2.423**	2.393**	2.574**
$\sigma_{Senti,t} \rightarrow Senti_t$	1.834*	1.834*	1.834*
$\sigma_{Senti,t} \rightarrow \sigma_t$	1.856*	1.723	2.255**

The table reports causality tests (*F*-statistics), following the VAR model of Eq. (6.3). *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively, i.e., rejection of the null of no Granger causality.

earning growth rates and investor sentiment are linked together and whether any unexpected change in investor sentiment and/or investor sentiment volatility has an effect on either earnings or earnings volatility.

The number of lags to be included is chosen using Akaike's (1973) and Schwarz's (1978) Bayesian information criterion. Inspecting also the significance of the lagged values of the variables in Eq. (6.4) and whether these can jointly add explanatory power to the model (based on the F-test), we end up with six lags for all three cases: Capesize, Panamax, and dry bulk total.

Results of Granger causality tests are presented in Table 6.3. The null hypothesis of no Granger causality is tested using an *F*-test, to check whether all coefficients of the lagged values of a particular explanatory variable can be jointly equal to zero. The hypothesis cannot be rejected if and only if the lagged terms of a variable can be retained in the regression based on the *F*-test. Overall, the figures indicate the existence of a two-way feedback mechanism: between (1) earnings and investor sentiment, (2) earnings and sentiment volatility, (3) earnings volatility and investor sentiment, and (4) earnings volatility and sentiment volatility. Additionally, sentiment volatility does not Granger cause sentiment while, overall, volatilities of earnings do cause earnings.

Overall, these findings indicate strong linkages among the considered variables and provide additional information beyond the analysis in the previous section. It seems that sentiment has a significant impact on the formation of dry bulk earnings through both channels of volatility and index levels. At the same, time shifts in optimism or pessimism in the market (as expressed by the constructed index) is also affected by earnings.

Finally, making use of the VAR model, we examine the implied impulse response functions (IRFs) of earnings with respect to total sentiment; impulse responses can be used to explore the adjustments across different markets to unexpected shocks in the variables of the system. Fig. 6.3 displays the generalized impulse responses (Pesaran & Shin, 1998) of the earnings and earnings volatilities to a 1 SD increase in the investor sentiment and sentiment volatility. The figure contains three rows of IRFs, each corresponding to a different definition of earnings, i.e., dry, Capesize, and Panamax. The dashed lines on each graph represent the upper and lower 95% confidence band. When the upper and lower bands carry the same sign, the response becomes statistically significant. On each graph, percentage growth rates/volatilities are plotted on the vertical axis and time (assumed impact period of 24 months) on the horizontal axis.

First, overall, there is a significant negative impact of the total sentiment on the earnings, left column of the graph. For the most part, the responses are significant in the short-term (less than 12 months) and then significance disappears during the remaining periods. However, as the impact period increases the response increases gradually, and in the long-term (more than 18 months ahead) sentiment impact reverses, i.e., it does not work as a contrarian indicator. Second, there seems to be a significant (between 10 and 18 months ahead), yet small in magnitude (less than 2%), negative impact of the total sentiment volatility on the earnings (second column of Fig. 6.3). During the first 2−3 months, sentiment volatility increases can create a temporary increase in industry earnings (only dry bulk). Third, the effect that sentiment has on earnings volatility is significantly positive but rather medium-term (third column of Fig. 6.3), in the period of more than 6 and less than 20 months. Finally, the right column of the figure shows that sentiment volatility and earnings volatility are positively related with the relationship being particularly significant for Panamax vessels, while the effect seems to be rather delayed.

Summing up, our results show that fluctuations in earnings are driven by shocks to investor sentiment and sentiment volatility; the former effect is both short- and long-term while the latter has a medium-term effect. In addition, movements in the volatility of earnings are also driven by sentiment; we find that such shocks have a significant medium- to long-term impact.

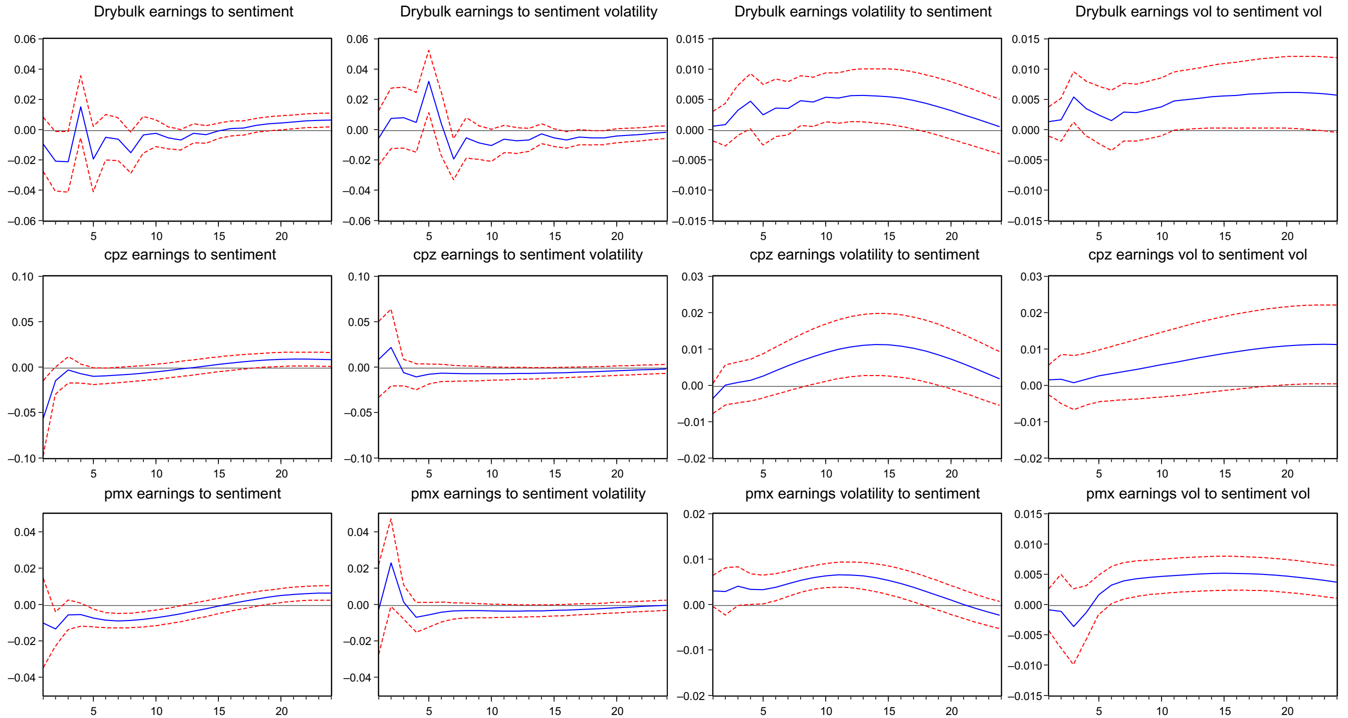

Figure 6.3 Response to generalized 1 SD innovations ± 2 SE.

6.4 CONCLUSION

Every shipping company faces the challenge of navigating its way through the succession of market peaks and troughs which characterize the shipping market and to take advantage of potential opportunities. In prosperous markets, businesses must meet the challenge of investing wisely for future growth, while in recessionary periods, when cash flows are squeezed, the challenge is to mitigate the negative impact when the market is forcing surplus capacity out. Therefore, market participants should acknowledge the impact of investor sentiment while establishing investment strategies. This chapter investigates the role of investor sentiment (time evolution of optimism and pessimism in the market) in the dry bulk subsectors of the international shipping industry for different vessel types. In doing so, it adds to the limited understanding of investor sentiment impact on earnings and volatility in shipping markets. Results indicate that the market sentiment index has a significant impact on the conditional mean and variance of the market earnings growth rates, while there is a feedback (bidirectional) relationship between investor sentiment and dry bulk vessel earnings. This chapter highlights the importance of taking into consideration and incorporating information produced by sentiment indices into the commercial, operational, and financial decisions relating to the assets (vessels) in the dry bulk shipping industry. Our results may also help policy makers to stabilize investor sentiment and, as such, reduce volatility and uncertainty, as sentiment provides economically significant incremental information for predicting earnings and the corresponding volatility.

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CHAPTER 7

Tail Risks in Credit, Commodity, and Shipping Markets

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7.1 INTRODUCTION

One of the industries directly affected by the fluctuations and changes in the world economy is shipping. Although, starting out decades ago as the mode to move finished goods and raw materials within short haul, shipping has become slowly but steadily an international industry which essentially connects large sectors of the economy. The Dry Bulk market, which deals with the transportation of iron ore, coal, grain, agricultural, and steel products among others, and the Tanker market, which is associated mainly with energy commodities constitute the major components of the world shipping industry. Due to these characteristics, developments in the shipping market are strongly affected by the growth of international trade. Adland and Cullinane (2006), Alizadeh and Nomikos (2007), and Goulas and Skiadopoulos (2012) *inter alia* document that the shipping market is highly risky and volatile, since it is subject to a number of uncertainties, ranging from geopolitical shocks, and the ever-changing world economy.

Over the last decade, the shipping industry has gone through extreme up and downturns. The recent financial meltdown which began in industrialized countries during 2007 and quickly spread to emerging markets, deteriorated the environment for capital flows, and triggered deep sell-offs in global economies. Investors pulled capital from countries, even those with small levels of perceived risk and caused the shipping industry, commodities, and global stock markets to plunge. Historically, global recessions are followed or supplemented by major falls in the shipping indices such as the dramatic drop in the Baltic Dry Index (BDI) in 2008–2009 when the index slumped by 94%. Motivated by the impact of the recent crisis, which provoked a rapid decline in world trade, we

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intend to answer the following questions: what is the dependence formation between shipping and financial, commodity, and credit markets? Is there any extreme value dependence (tail risk) over and above what one would expect from economic fundamentals which assembles to contagion? Is the dependence symmetric or asymmetric? By answering these questions, we investigate the extent to which shocks to stock, commodity, and credit markets are transmitted to fluctuations in the shipping market and shed light into the most recent shipping cycle, which peaked in 2008 before declining rapidly at the onset of the global financial crisis.

We employ and compare several copula functions with different dependence structures (i.e., Gaussian, Student-*t*, and Symmetrized Joe Clayton) in order to model and examine conditional dependence and tail dependence between the Dry Bulk market (BDI, Baltic Panamax Index (BPI), Baltic Capesize Index (BCI)), the Tanker market (Baltic Dirty Tanker Index (BDTI)), the financial market (S&P 500 stock Index), commodities (S&P Goldman Sachs Commodity Index (S&P GSCI)), and credit markets (iTraxx Senior Financials Index for Banks' Credit Default Swaps (BCDS) and Volatility Index (VIX) representing changes in credit markets).[1]

We find evidence of significant and symmetric lower tail dependence during the financial crisis, implying that the interactions of financial, commodity, and credit markets determine the systemic risks that drive the shipping crisis. This finding has important risk and asset pricing implications, since left-tail dependence indicates the potential of simultaneous large losses. Moreover, this finding implies that accelerated decreases in the financial markets, in the commodity index, and large variations in credit markets lead to accelerated decreases and increased fluctuations in the shipping market. We also find that the Dry Bulk market is more volatile and more vulnerable to downside risks from the Tanker market and that the category of vessels of higher tonnage (i.e., Capesize vessels) is more volatile and susceptible to downside risks than

[1] According to Jorion and Zhang (2007) and Alexander and Kaeck (2008), Credit Default Swaps spreads drive the movements in credit spreads and provide an indicator for the credit health of a firm. Similarly, we employ BCDS spreads as a driver for the credit conditions (e.g., funding). The VIX is an implied volatility index based on options on the S&P 500 stock Index and is used as a proxy to evaluate credit market risk, similar to Collin-Dufresne, Goldstein, and Martin (2001) and Alexander and Kaeck (2008) who use the VIX and the VSTOXX as the best available substitute for their dataset, respectively.

vessels of medium range tonnage (i.e., Panamax vessels). The significance of the tail dependence implies that stock, commodity, credit markets, and the shipping market tend to experience concurrent extreme shocks. This joint downside risk has not been documented in the literature previously.

Moreover, we document that the comovement becomes stronger during the crisis period, consistent with contagion between asset prices when compared with tranquil periods. Concretely, large adverse shocks to stock, commodity, and credit markets are associated with a significant increase in the probability of the shipping market resembling contagion. We call these variables, contagion channel variables—that is, variables whose extreme adverse realizations are associated with a slump of shipping indices. To our knowledge, this is the first study to test for and document the existence of shipping market contagion. We define contagion in this study as a significant increase in cross-market linkages during periods of high volatility, which is over and above what one would expect from economic fundamentals, similar to other works in this literature (see, e.g., Forbes & Rigobon, 2002; Bekaert, Harvey, & Ng, 2005; Yuan, 2005; Boyer, Kumugai, & Yuan, 2006; Kenourgios, Samitas, & Paltalidis, 2011; Jotikasthira, Lundblad, & Ramodarai, 2012) who show that correlations among market returns are especially large during market downturns, indicating that contagion may be asymmetric. Furthermore, spillovers during the financial meltdown can be attributed to the channel running from stock, commodity, and credit markets shocks to the shipping market. This finding allows investors to measure the probability of simultaneous extreme losses.

Additionally, we observe that dependence remains significant but weaker after the financial crisis and the shipping market becomes more pronouncedly heavy tailed in downward moves than in upward moves. This finding indicates statistically significant decreases in the tail indices and structural breaks due to the recent financial crisis that corresponds to the increase in the likelihood of large fluctuations. As a result, in the post-crisis period, the shipping market is more susceptible to financial crisis and to speculative attacks. The increased likelihood of extreme joint losses suggests a higher than normal value at risk.

On the other hand, we find that there exists significant comovement and asymmetric tail dependence for the precrisis period, implying that there is asymmetry in upward moves between shipping, financial, commodity, and credit indices. These findings also affect the pricing of assets. For instance, tail dependence is extremely important for safety-first investors. In addition, tail dependence is a measure of systematic risk during severe financial conditions as discussed by Allen and Carletti (2013). Finally, this study improves the understanding of risks in the shipping market in two ways: (1) via identifying that accelerated decreases in commodities and prompt variations in volatility provoke accelerated decreases in, and function as a barometer of, shipping market fluctuations and (2) via proposing the VIX as a proxy for hedging risk exposures in the shipping market.

The rest of this study is organized as follows: Section 7.2 describes the literature review, Section 7.3 outlines the methodology used in this research, Section 7.4 describes the characteristics of the dataset, Section 7.5 analyses the estimation results, Section 7.6 provides robustness checks, and finally Section 7.7 presents the concluding remarks.

7.2 LITERATURE REVIEW

By contrast to the traditional asset pricing theory, the presence of irrational investors in a market with frictions and noise traders, advances to increased correlation and comovements, which are over and above any macroeconomic fundamentals advancing to contagion (see also Bekaert et al., 2005). Similarly, we employ contagion in this study as a metric which increases cross-market linkages during periods of high volatility and propose that forced sales or "fire sales" in the contagion channels (i.e., financial, commodity, and credit markets) affect the shipping market (similar to Jotikasthira et al., 2012; for effects of fire sales in emerging markets). Following Yuan (2005), uninformed rational investors are not able to distinguish between selling based on liquidity shocks and fundamental shocks. Thus large losses in an investment, point to cross-market portfolio rebalancing (see also Boyer et al., 2006), and causes cross-asset depreciation.

Studies on volatility transmission and contagion literally exploded since the thought-provoking papers by Forbes and Rigobon (2002). The global financial crisis that followed the collapse of Lehman Brothers in September 2007 triggered an unprecedented deterioration in the world's major advanced economies and the banking system (see also Paltalidis, Gounopoulos, Kizys, & Koutelidakis, 2015; Boubaker, Gounopoulos, Nguyen, & Paltalidis, 2017). The shipping market has gone into recession since the outbreak of the world credit crisis, which had a devastating and serious impact on the economy and finally dragged down the world economy into recession. However, studies that aim at the interactions in the shipping market are less frequent than those covering equity markets, with researchers observing strong implications of stock market integration and contagion.

Investors in shipping markets have always faced important and difficult decisions on investment and divestment timing because of the complex and volatile nature of the shipping industry (Alizadeh & Nomikos, 2007; Goulas & Skiadopoulos, 2012). Tezuka, Masahiro, and Ishizaka (2012) study freight rate risks in shipping forward contracts and employ several vector error correction models (VECM) and random walk models to obtain optimal forward hedge ratios. Shipping cycles are driven by combinations of external and internal factors that shape the long-term volatility of the shipping industry (Alizadeh, 2013).

After the last quarter of 2008, the spectacular surge was replaced by the perfect storm in which everything that could go wrong did go wrong, culminating in the worst possible catastrophe in the shipping industry. The sinking freight rates, the decreased demand for shipping services, the plunging of vessel values, the numerous laid-up vessels were just some of the consequences of the global economic crisis. Our study opens a new way and sheds light on the importance of contagion between shipping, financial, commodity and credit markets. In particular, Bekaert and Harvey (1995, 2000) are among the first to identify cross-border linkages of stock markets. Karolyi and Stulz (1996) and Bodart and Reding (1999) are among the first that examine spillovers between the developed US stock market and foreign exchanges. They find no evidence of volatility spillovers between the foreign exchange and stock market returns. In particular, they observe that the value of the dollar is negatively related to changes in US stock markets in the long run. On the other hand, Longin and Solnik (2001), Ang and Bekaert (2002, 2005), Yuan (2005), Boyer et al. (2006), Kenourgios et al. (2011), and Jotikasthira et al. (2012), document that comovement among market returns during market downturns are over and above any economic reasoning, resembling to contagion.

7.3 METHODOLOGY

7.3.1 The Hypotheses

The presence of risk in financial decision-making advances the importance of dependence in decisions involving more than one risky asset. Our study complements the literature with the methodological approach used to analyze the movement of the shipping indices. Most researchers use VECM and vector autoregressive (VAR) models to analyze the information contained in the movement of the BDI. The versatile nature of copulas makes them suitable to be used in a broad range of financial situations. Copulas offer financial risk managers a powerful tool to model the dependence between the different elements of a portfolio and are preferable to the traditional, correlation-based approach. As investors are generally averse to downside risk, a copula function captures both the risk of joint downward movements of asset prices, and the diversification opportunities that assets offer. For instance, the existence of comovements implies that the variance of return on a risky asset depends on the variances of another asset and on the degree of correlation between these assets in the portfolio. Thus copula functions are more appropriate to adequately capture fat tails and higher moments than a bivariate normal distribution.[2]

In this study we analyze the dependence structure of the shipping indices against the following indices: the S&P 500, the S&P GSCI, BCDS, and the VIX. We first provide the theoretical framework, and then employ linear measures of interdependence (Kendall's τ and Spearman's ρ). Due to the drawbacks of linear measures, we then introduce three copula-GARCH approaches (Gaussian, Student-*t*, and Symmetrized Joe Clayton) in order to identify the marginal distributions of the variables, to control for heteroscedasticity and examine the nature of the dependence and tail risks during market tranquil and turmoil periods. Also, in order to gain an even deeper insight into parameter changes we follow Aloui, Ben Assa, and Nguyen (2013) and build a rolling window of 90 days length (i.e., one-quarter of a trading year) to estimate the dependence parameter and the tail dependence coefficients.

Particularly, we use the time-varying nature of the copula functions to describe the distribution and dependence structure between the shipping market (BDI, BPI, BCI, BDTI), the financial market (S&P 500 Index), the commodity market (represented by the S&P GSCI), and the credit market represented by BCDS spreads and the VIX. Developments in the financial market reflect the global economic conditions (Markwat, Kole, & Van Dijk, 2009). For instance, during periods of economic expansion the stock markets are expected to surge. Thus, following this rationale we expect the shipping market to be correlated to some extent with the

[2] A thorough review of copulas may be found in Patton and Sheppard (2009).

movement of the stock market (at least for the precrisis period), reflecting strong demand for shipping services. Furthermore, an increase in the commodities market reflects strong demand for raw materials and, consequently, for transportation. Hence, we expect to observe positive dependence between commodity and shipping indices. On the other hand, periods of economic development are usually supported by credit expansion (Covitz, Liang, & Suarez, 2013). Thus during these periods uncertainty and volatility tend to be small and, consequently, BCDS spreads to be low and the VIX to be near historical lows (Jorion & Zhang, 2007; Alexander & Kaeck, 2008; Kizys, Paltalidis, & Vergos, 2016). Based on this foundation, we expect a negative relationship between the shipping indices and the VIX. We can now formulate our first hypothesis:

Hypothesis 1: There is a positive dependence structure between shipping, stock markets, and commodities. Positive (or negative) changes in stock market and commodity returns are followed by positive (or negative) changes in the shipping market. Accordingly, there is a negative dependence structure between the shipping market and changes in the VIX.

The investigation of dependence structure is crucial for risk management and portfolio diversification (Aloui, Ben Assa, & Nguyen, 2011). An increase in cross-asset comovements renders traditional diversification theory fruitless (Markowitz, 1952; Solnik, 1974). Moreover, the literature notifies that contagion occurs when cross-market dependence increases over and above any macroeconomic fundamentals (Karolyi & Stulz, 1996; Forbes & Rigobon, 2002; Bekaert et al., 2005). Investors are not able to distinguish between selling based on liquidity shocks and fundamental shocks (Yuan, 2005). Thus when confused investors suffer a large loss in an investment, they have to liquidate their positions in other investments using forced sales or "fire sales" (similar to Jotikasthira et al. (2012) for fire sales in emerging markets). Forced sales cause cross-market portfolio rebalancing and liquidation (see also Boyer et al., 2006), and thus lead to cross-asset depreciation. Additionally, Jorion and Zhang (2007) and Markwat et al. (2009) observe that credit events and stock market crashes create domino and cross-market contagion effects. Similarly, we formulate our second hypothesis:

Hypothesis 2: During severe financial conditions comovement increases. Shocks and fluctuations in financial, commodity, and credit markets perform as contagion channels whose extreme adverse realizations are associated with a slump of the shipping indices. Fluctuations and elevated volatility strengthens *informational contents of stock, commodity, and credit markets and raises uncertainty. The extreme value dependence is over and above what one would expect from economic fundamentals, pointing to contagion. Consequently, investors will demand higher risk premium in order to invest in the shipping indices, triggering deep sell-offs of the shipping market.*

Longin and Solnik (2001) and Ang and Bekaert (2002), among others, document that there is asymmetric correlation between financial markets in bear and bull periods, resembling asymmetric contagion. Similarly, we formulate our third hypothesis:

Hypothesis 3: The dependence structure and contagion are asymmetric, so that upper and lower tail dependence coefficients are not exactly equal. During negative correlation regimes and severe financial conditions, lower tail dependence is higher than upper tail dependence. Furthermore, dependence and upper tail dependence are asymmetric for the shipping market in a positive correlation regime. In our approach, upper (lower) tail dependence measures the dependence between the shipping indices when these are appreciating (depreciating) against the financial, commodity, and volatility indices.

7.3.2 Marginal Distributions

Following Patton (2006), for a joint distribution function, the marginal distributions and the dependence structure can be separated as described below:

$$F_{XY}(x, y) = C(F_X(x), F_Y(y)), \text{ or} \tag{7.1}$$

$$f_{xy}(x, y) = f_x(x) \bullet f_y(y) \bullet c(F_X(x), F_Y(y)) \tag{7.2}$$

The central result in copula theory states that any continuous N-dimensional cumulative distribution function F, evaluated at point $x = (x_1, \ldots, x_N)^{(5)}$ can be represented as:

$$F(x) = C(F_1(x_1), \ldots F_N(x_N)) \tag{7.3}$$

where C is a copula function and $F_i i = 1, \ldots, N$ are the margins.

Copulas are very flexible in analyzing comovement and modeling dependence. Various copulas represent different dependence structure between variables, a property which provides us with more options in model specification and estimation.

Formally, a two-dimensional (bivariate) copula is a function $C\ : [0, 1] \times [0, 1] \rightarrow [0, 1]$, such that:

1. $C(u,0) = C(0,v) = 0$(C is grounded),
2. $C(u,1) = u$ and $C(1,v) = v$, (consistent with margins)
3. for any $u_1, u_2, v_1, v_2 \in [0,1]$ with $u_1 \leq u_2$ and $v_1 \leq v_2$,

$$C(u_2,v_2) + C(u_1,v_1) - C(u_1,v_2) - C(u_2,v_1) \geq 0(2 - \text{increasing})$$

Copulas are more informative measures of dependence between many variables than linear correlations, since they provide us with the degree of the dependence and the structure of the dependence. The copula function can directly model the tail dependence, while linear correlation does not provide information about tail dependence and the symmetry property of the dependence. Hence, any copula function has a lower and an upper bound, C^- and C^+, which are known as the minimum and the maximum copula, respectively. For any point $(u,v) \in [0,1] \times [0,1]$ the copula must lie in the interval as follows:

$$C^-(u,v) \equiv \max(u+v-1,0) \leq C(u,v) \leq \min(u,v) \equiv C^+(u,v).$$

As with standard distribution functions, copulas have associated densities which exist in the interior domain as given by:

$$c(u,v) = \frac{d^2C(u,v)}{dudv} \tag{7.4}$$

The Eq. (7.4) permits the canonical representation of a bivariate density $f(u,v)$ as the product of the copula density and the density functions of the margins as given by:

$$f(u,v) = c(F_1(u), F_2(u))f_1(u)f_2(v) \tag{7.5}$$

Eq. (7.5) indicates how the product of two marginal distributions will fail to properly measure the joint distribution of two asset prices unless they are in fact independent. The dependence information captured by the copula density, $c(F_1(u), F_2(u))$, is normalized to unity and shows that copula functions are an alternative dependence measure that is reliable when correlation is not.

Based on the work of Nelson (1991) and Bollerslev (1986), we estimate the dependence described earlier, with a GARCH type model. The daily return is expressed as:

$$R_t = \mu_t + \varepsilon_t = \mu_t + \sigma_t z_t, z_t \sim iid(0,1)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2, \tag{7.6}$$

where μ_t denotes the conditional mean and σ_t^2 is the conditional variance with parameter restrictions $\omega > 0$, $\alpha > 0$, $\beta > 0$, and $\alpha + \beta > 1$. We use the AIC and BIC criteria to determine the optimal lag length for the conditional mean process and these criteria select $m = 1$ and $n = 1$ for all variables. Given a time series y_t, the GARCH (1,1) model is described as:

$$y_{t=}c + \sigma_t z_t$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{7.7}$$

where z_t is an *iid* random variable with zero mean and variance of one. σ_t^2 is the conditional variable of return series at time t, with the same restrictions as noted in Eq. (7.6).

7.3.3 Copula Models

As noted by Patton (2006), Kenourgios et al. (2011), and Aloui et al. (2013), copula functions can be used to characterize the dependence in the tails of the distribution. Upper and lower tail dependence coefficients can be used to measure and capture booms and crashes.

We assume that the variables of interest in our model are X and Y with marginal distribution functions F and G. Thus the coefficient of lower tail dependence λ_L is represented as:

$$\lambda_L = \lim_{t \to 0^+} \Pr[Y \le G^{-1}(t) | X \le F^{-1}(t)] \tag{7.8}$$

which quantifies the probability of observing a lower Y assuming that X is lower itself.

Similarly, the coefficient for the upper tail dependence λ_U is defined by:

$$\lambda_U = \lim_{t \to 1^+} \Pr[Y > G^{-1}(t) | X > F^{-1}(t)] \tag{7.9}$$

Thus symmetry occurs when the lower tail dependence equals the upper tail dependence coefficient, otherwise there is asymmetry.

The Gaussian copula symmetry occurs when $\lambda_l = \lambda_u$.

As a result, the Gaussian normal copula can be expressed as:

$$C(u, v) = \Phi_\theta\left(\Phi^{-1}(u), \Phi^{-1}(v)\right)$$
$$= \int_{-\infty}^{\Phi^{-1}(u)} \int_{-\infty}^{\Phi^{-1}(v)} \frac{1}{2\pi\sqrt{1-\theta^2}} \exp\left(-\frac{s^2 - 2\theta st + t^2}{2\left(1-\theta^2\right)}\right) ds dt \tag{7.10}$$

where Φ_θ is the standard bivariate normal distribution with linear correlation coefficient θ restricted to the interval $(-1, +1)$, and Φ represents the univariate standard normal distribution function.

Similarly, the Student-t copula can be defined as:

$$C(u,v) = \int_{-\infty}^{t_u^{-1}(u)} \int_{-\infty}^{t_u^{-1}(v)} \frac{1}{2\pi\sqrt{1-\theta^2}} \exp(1 + \frac{s^2 - 2\theta st + t^2}{u(1-\theta^2)})^{-\frac{u+2}{2}} ds dt \quad (7.11)$$

where $t_u{}^{-1}(u)$ denotes the inverse of the cumulative distribution function of the standard univariate Student-t distribution with u degrees of freedom.

The comovement between an asset and the shipping market could be positive or negative depending on the strength of the volatility chasing effect. Hence, the comovement between assets switches between positive and negative dependence regimes. To capture the earlier dependence switching, this study proposes the Symmetrized Joe Clayton copula as proposed by Patton (2006) for the dependence structure, since this copula allows for asymmetric tail dependence and nests symmetry as a special case. Therefore:

$$\begin{aligned} C_{SJC}\left(u,\ v\middle|\tau^U,\tau^L\right) = 0.5(C_{JC}\left(u,\ v\middle|\tau^U,\tau^L\right) + C_{JC}(1-u, 1-v\middle|\tau^U,\tau^L) \\ + u + v - 1 \end{aligned} \quad (7.12)$$

where C_{SJC} is the Joe Clayton function defined as:

$$C_{JC}(u,v\middle|\tau^U,\tau^L) = 1 - (1-\{[1-(1-u)^\kappa]^{-\gamma} + [1-(1-v)^\kappa]^{-\gamma} - 1\}^{-1/\gamma})^{1/\kappa} \quad (7.13)$$

where $\kappa = 1/\log_2(2-\tau^U)$

$$\gamma = -1/\log_2(\tau^L)$$

and

$$\tau^U \epsilon (0,1), \tau^L \epsilon (0,1) \quad (7.14)$$

From Eqs. (7.12) and (7.13) the Joe Clayton copula has two parameters, τ^U and τ^L, which are measures of tail dependence,[3] as defined in Patton (2006). The Joe Clayton copula symmetry occurs when $\tau^U = \tau^L$.

[3] For details and the mathematical representation, see Patton (2006) and Kenourgios et al. (2011).

7.4 DATA AND DESCRIPTIVE STATISTICS

Using Bloomberg, Datastream, and Clarksons databases, we collected daily data observations for the BDI, the BPI, the BCI, the BDTI, the S&P 500 stock market index, the S&P GSCI, the iTraxx Senior Financials (Banks' Credit Default Swap spreads), and the VIX. Our research deals with the recent financial crisis and identifies the time-varying dependence structure between different asset classes. Before the subprime mortgage crisis (i.e., before July 2007), the shipping market experienced low volatility, with the shipping indices moving upward. Since the collapse of Lehman Brothers (September 2008), the shipping indices experienced an unprecedented increase in volatility. These developments are depicted in Panel A of Fig. 7.1.

Credit default swap (CDS) contracts are derivative contracts that allow investors in an underlying debt instrument to protect themselves against a deterioration of credit quality or credit conditions. The iTraxx Senior Financials Index comprises the 25 largest banks based on their capitalization and represents the credit conditions in the financial sector. An increase in the price of BCDS indicates deterioration in credit market conditions. The VIX is a popular measure of the implied volatility of the S&P 500 index options for the Chicago Board Options Exchange Market Volatility Index and represents a measure of the market's expectation of stock market volatility. The S&P GSCI is a benchmark for investment in the commodity market and a measure of commodity performance over time. It is a tradable index that is readily available to market participants of the Chicago Mercantile Exchange. The index comprises 24 commodities from all commodity sectors—energy products, industrial metals, agricultural products, livestock products, and precious metals. The wide range of constituent commodities provides the S&P GSCI with a high level of diversification.

We present summary statistics in Table 7.1 (sample mean, median, maximum, minimum, standard deviation, skewness, excess kurtosis, the Jarque−Bera test statistic, and the *P*-value associated with the Jarque−Bera test statistic). Over the sample period, the mean of the shipping indices is negative (i.e., for the BDI, −1.4649 basis points) reflecting greater risk for investments in the shipping market. The biggest risk is observed for the BCI (−1.8871) and the least risk for the Tanker market (−0.4853). Moreover, all shipping indices are negatively skewed (BDI: −1.072, BPI: −0.459, BCI: −2.008, BDTI: −1610) and

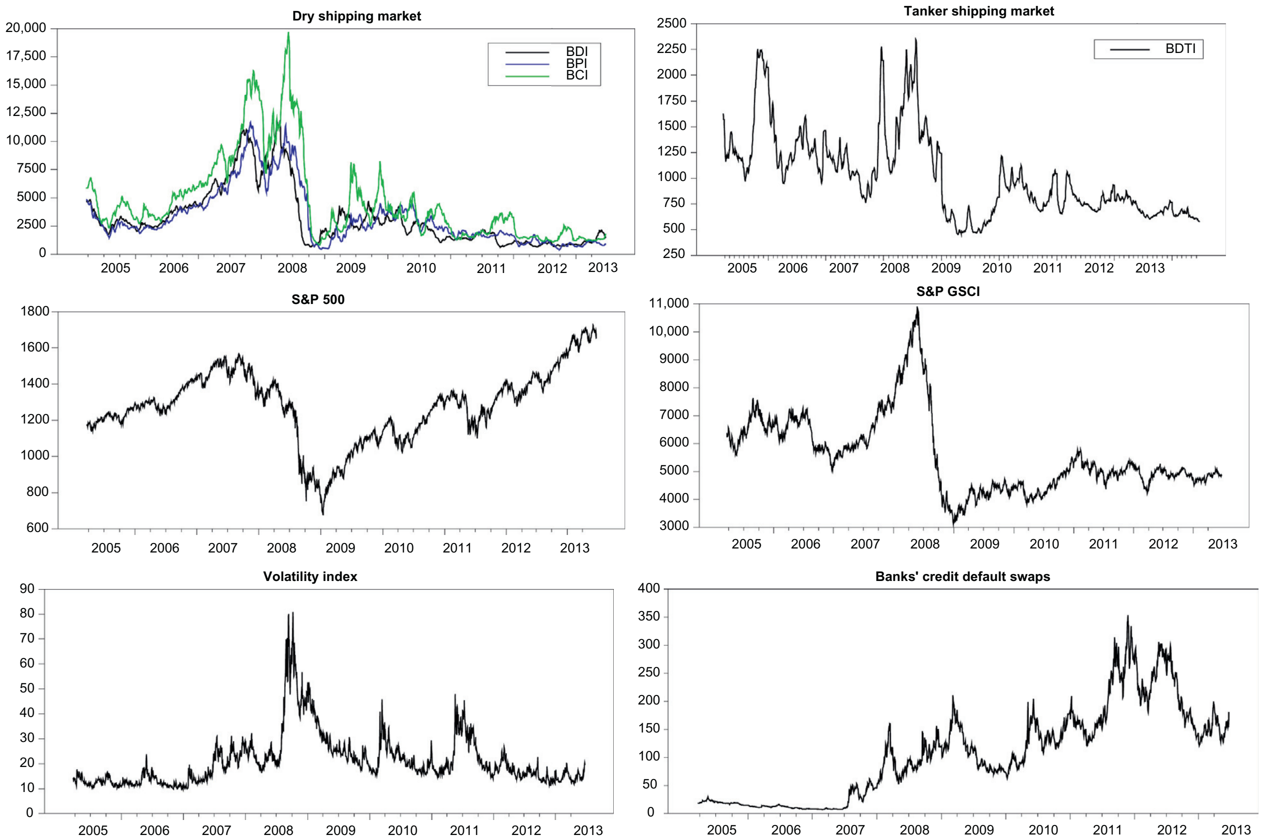

Figure 7.1 Daily movements of shipping, financial, commodity, and credit markets. *The dataset has been constructed from Bloomberg and Datastream.*

Table 7.1 Summary statistics

Variables	Obs	Mean	Median	Max.	Min.	Std.	Skew	Kurt	JB	Prob.
BDI	2153	− 1.4649	2.501	11.793	647	2551.0	− 1.072	16.309	24275	0.0000
BPI	2153	− 1.8086	2.400	11.713	418	2507.5	− 0.459	9.973	8999	0.0000
BCI	2153	− 1.8871	3.459	19.867	830	3775.1	− 2.008	37.623	128431	0.0000
BDTI	2153	− 0.4853	930	2.347	453	405.58	− 1.610	36.779	122280	0.0000
S&P 500	2153	0.2251	1.287	1.725	676	1984.9	− 0.412	5.600	2874	0.0000
S&P GSCI	2153	0.0001	5.111	10.898	3116	1399.0	− 0.140	2.688	655	0.0000
VIX	2153	0.0024	− 0.0900	16.5400	− 17.3600	1.9732	0.545	16.891	25702	0.0000
BCDS	2153	106.8703	101.3290	353.0000	7.0000	81.9862	0.5518	2.5016	131.5949	0.0000

Note: This table presents summary statistics (standard deviation, skewness, excess kurtosis, the Jarque−Bera test statistic, and the *P*-value associated to the Jarque−Bera test statistic) of the change in shipping indices (Baltic Dry Index, Baltic Panamax Index, Baltic Capesize Index, Baltic Dirty Tanker Index, measured in basis points), the change in the financial market (S&P 500, measured in basis points), the change in the commodity market (S&P GSCI, measured in index points), the iTraxx Senior Financials Index (Banks' Credit Default Swaps spreads or BCDS) and the change in the Volatility Index, measured in percentage points. The sample period is 22/03/2005−21/06/2013 and contains a total of 2153 daily observations.

highly leptokurtic (BDI: 16.309, BPI: 9.973, BCI: 37.623, BDTI: 36.779), implying that the distributions depart from symmetry. The resulting distribution is nonnormal, since the normality is rejected by the Jarque–Bera test statistic. The shipping market experienced significant fluctuations over the sample period, as indicated by the range of variation in the standard deviation. The latter indicates that the change in the BDI deviated from the mean on average by 2551 index points, in the BPI by 2507 index points, in the BCI by 3775 index points and in the tanker market by 405 basis points.

Stock (S&P 500) and commodity (S&P GSCI) returns were less volatile, as suggested by the range of variation and the standard deviation. Daily percentage stock and commodity returns were positive during the sample period (S&P: +0.2251%, S&P GSCI: +0.0001%). Consistent with empirical evidence on skewness and kurtosis, returns are negatively skewed and leptokurtic, suggesting that big negative events in the stock and commodity markets are more likely than big positive events and that the density of returns is greater the closer returns are to the sample median. Therefore, the resulting distribution of returns is nonnormal.

Over the sample period, the mean of the BCDS spread (106.87 basis points) reflects an increasing credit default risk of the banking sector. BCDS also was very volatile, as witnessed by the range of variation of the data (the difference between the minimum and maximum values) and by the standard deviation. The resulting distributions are nonnormal, since the normality is rejected by the Jarque–Bera test statistic. The change in the VIX has a positive mean, suggesting that the expectations of market volatility were increasing over the sample period. The change in the VIX is also positively skewed and highly leptokurtic resulting in a nonnormal distribution of values.

7.5 EMPIRICAL FINDINGS

7.5.1 Copula Functions

We analyze dependence and tail dependence separately for the period from March 2005 to August 2007 (precrisis period), August 2007 to September 2009 (crisis period), and September 2009 to June 2013 (postcrisis period). We start by interpreting the results of the rank correlation coefficients (Table 7.2) as applied to the shipping market, financial market, commodity, and volatility indices. We observe that for the overall sample period there is positive dependence and comovement—Kendall's τ and

Table 7.2 Correlation estimates of shipping, stock market, commodity, and volatility indices

Variables	Overall sample		Precrisis period		Crisis period		Postcrisis period	
	Kendall-τ	Spearman-ρ	Kendall-τ	Spearman-ρ	Kendall-τ	Spearman-ρ	Kendall-τ	Spearman-ρ
BDI/S&P 500	0.149	0.173	0.152	0.179	0.226	0.285	0.061	0.077
BDI/S&P GSCI	0.153	0.195	0.160	0.187	0.230	0.306	0.110	0.113
BDI/VIX	− 0.071	− 0.029	− 0.116	− 0.062	0.056	0.070	− 0.016	− 0.004
BDI/BCDS	− 0.053	− 0.017	− 0.094	− 0.058	0.038	0.045	0.013	0.022
BPI/S&P 500	0.116	0.120	0.127	0.129	0.173	0.189	0.028	0.035
BPI/S&P GSCI	0.128	0.144	0.142	0.157	0.180	0.203	0.057	0.066
BPI/VIX	− 0.067	− 0.021	− 0.083	− 0.076	0.017	0.034	− 0.028	− 0.021
BPI/BCDS	− 0.049	− 0.015	− 0.072	− 0.050	0.032	0.041	0.011	0.019
BCI/S&P 500	0.128	0.137	0.136	0.151	0.203	0.228	0.047	0.062
BCI/S&P GSCI	0.142	0.174	0.149	0.171	0.209	0.245	0.050	0.061
BCI/VIX	− 0.068	− 0.023	− 0.090	− 0.072	0.033	0.052	− 0.020	− 0.016
BCI/BCDS	− 0.050	− 0.014	− 0.095	− 0.062	0.052	0.064	0.018	0.029
BDTI/S&P 500	0.089	0.104	0.093	0.116	0.128	0.144	0.011	0.016
BDTI/S&P GSCI	0.092	0.110	0.107	0.118	0.129	0.146	0.037	0.052
BDTI/VIX	− 0.031	− 0.019	− 0.058	− 0.047	0.022	0.036	− 0.019	− 0.012
BDTI/BCDS	− 0.030	− 0.017	− 0.046	− 0.032	0.013	0.021	0.002	0.004

Note: This table summarizes rank correlation estimates for shipping, financial, commodity, and credit dependence for the overall period and three subperiods. Positive significance implies increased correlation and dependence.

Spearman's ρ statistics are positive—between the shipping indices, the stock market, and the commodity index, indicating that the probability of concordance is significantly higher than the probability of discordance. On the other hand, as expected, there is negative dependence for all considered pairs with the BCDS (iTraxx Senior Financials) and the VIX. The results also imply that the Dry Bulk Indices (BDI, BPI, BCI) experience higher dependence than the Tanker Index (BDTI), indicating that the response of the Dry Bulk market is significantly quicker to changes and fluctuations in other markets.

The strongest relationship is observed between the shipping indices and the commodity index. The Kendall's τ and the Spearman's ρ are 0.153 and 0.195 accordingly for the BDI, 0.142 and 0.174 for the BCI, 0.128 and 0.144 for the BPI and 0.092 and 0.110 for the BDTI. Positive dependence indicates that the booming demand for commodities has underpinned the shipping market. During the crisis period the dependence increases substantially—Kendall's τ and Spearman's ρ rise to higher levels for all considered pairs—implying that negative shocks in the stock market and the commodity index have a stronger effect on the shipping market. This finding indicates that the shipping indices display a significant reversal, following shocks to financial and commodity markets. In the postcrisis period, the dependence structure weakens—Kendall's τ and Spearman's ρ decrease for all considered pairs—reflecting a structural break or a regime shift that divides the behavior of the shipping market.

Moreover, we find relatively smaller but also positive dependence between the shipping indices and the financial market. Again, this relationship becomes stronger during the crisis period. On the other hand, for the overall sample, both Kendall's τ and Spearman's ρ statistics are negative between the shipping indices, the BCDS spreads and the VIX, implying that there is no comovement. However, during the crisis period, the significantly negative response is reversed and the dependence becomes positive, implying that during high-volatility periods, where uncertainty increases and credit markets become squeezed, changes in the BCDS spread and in the VIX are followed by significant changes in the shipping market. Indeed, during the financial crisis the VIX increased substantially while fluctuations soared in the shipping market. These relationships also indicate that the VIX can be used as a hedging proxy for investments in the shipping market.

We report the estimation results of the dependence parameters for the shipping market in Table 7.3. The copula parameter estimates are

Table 7.3 Estimates of copula dependence parameters—overall sample

Variables	Gaussian	Standard error	Student-*t*	Standard error	Symmetrized Joe Clayton	Standard error
BDI/S&P 500	0.244	0.021*	0.262	0.023*	0.215	0.019*
BDI/S&P GSCI	0.249	0.021*	0.277	0.024*	0.223	0.019*
BDI/VIX	− 0.006	0.010	− 0.002	0.010	− 0.007	0.010
BDI/BCDS	− 0.004	0.010	− 0.001	0.011	− 0.006	0.010
BPI/S&P 500	0.213	0.019*	0.228	0.022*	0.211	0.019*
BPI/S&P GSCI	0.221	0.019*	0.236	0.021*	0.218	0.019*
BPI/VIX	− 0.003	0.010	− 0.001	0.011	− 0.003	0.010
BPI/BCDS	− 0.002	0.010	− 0.002	0.010	− 0.003	0.010
BCI/S&P 500	0.226	0.019*	0.253	0.022*	0.224	0.019*
BCI/S&P GSCI	0.230	0.020*	0.257	0.022*	0.233	0.020*
BCI/VIX	− 0.004	0.010	− 0.001	0.011	− 0.004	0.010
BCI/BCDS	− 0.003	0.010	− 0.002	0.010	− 0.003	0.010
BDTI/S&P 500	0.211	0.019*	0.224	0.019*	0.210	0.019*
BDTI/S&P GSCI	0.218	0.019*	0.229	0.020*	0.216	0.019*
BDTI/VIX	− 0.002	0.010	− 0.001	0.011	− 0.002	0.010
BDTI/BCDS	− 0.001	0.011	− 0.001	0.011	− 0.001	0.011

Note: This table presents the estimated copula dependence parameters for the Gaussian, Student-*t,* and Joe Clayton copula functions for the shipping indexes, the financial index S&P 500, the commodity index S&P GSCI, the credit market index iTraxx Senior Financials for Banks' Credit Default Swaps, and the Volatility Index for the overall sample period. Asterisk (*) indicates significance of coefficients at the 5% level.

significant, when the Gaussian, Student-*t*, and Joe Clayton copulas are applied. These findings support hypothesis 1 stating that there is a positive dependence structure between shipping, stock markets, and commodities. Thus positive (or negative) changes in stock market and commodity returns are followed by positive (or negative) changes in the shipping market. The strongest relationship is observed between the shipping indices and the commodity index. Again, the dependence for the Dry Bulk market is higher than the dependence for the Tanker Market. Indeed, the dependence structure between the BDI and the S&P GSCI is 0.249 when employing the Gaussian copula, 0.277 when employing the Student-*t* copula, and 0.223 when employing the Joe Clayton copula. On the other hand, the dependence structure between the BDTI and the S&P GSCI is 0.218 when employing the Gaussian copula, 0.229 when employing the Student-*t* copula, and 0.216 when employing the Joe Clayton copula (see also Fig. 7.2 for the estimated observations). Accordingly, as expected, there is a negative dependence structure between the shipping market and changes in the iTraxx Senior Financials Index (i.e., BCDS) and the VIX. During periods of economic and credit expansion (i.e., BCDS spreads decrease), freight rates tend to rise, and volatility tends to decline.

The dependence during the crisis period increases substantially for the shipping indices, supporting hypotheses 2. Indeed, during severe financial conditions comovement increases, shocks and fluctuations in financial, commodity, and credit markets perform as contagion channels whose extreme adverse realizations are associated with a slump in the shipping indices. Thus we observe extreme value dependence over and above what one would expect from economic fundamentals pointing to contagion. Fluctuations and elevated volatility strengthens the informational contents of stock, commodity, and credit markets and raises uncertainty. Consequently, investors demand higher risk premium in order to invest in the shipping indices, triggering deep sell-offs in the shipping market.

Furthermore, Table 7.4 and Fig. 7.3 show that the tail dependence when these markets are booming (upper and right tail) is not the same as that when markets are crashing (lower and left tail). Consequently, when lower tail dependence increases, comovements increase under severe financial conditions, causing asymmetry between upper and lower tails. These findings support hypothesis 3 which assumes asymmetric tail dependence and asymmetric contagion during high-volatility periods, and are in line with Longin and Solnik (2001), Ang and Bekaert (2002),

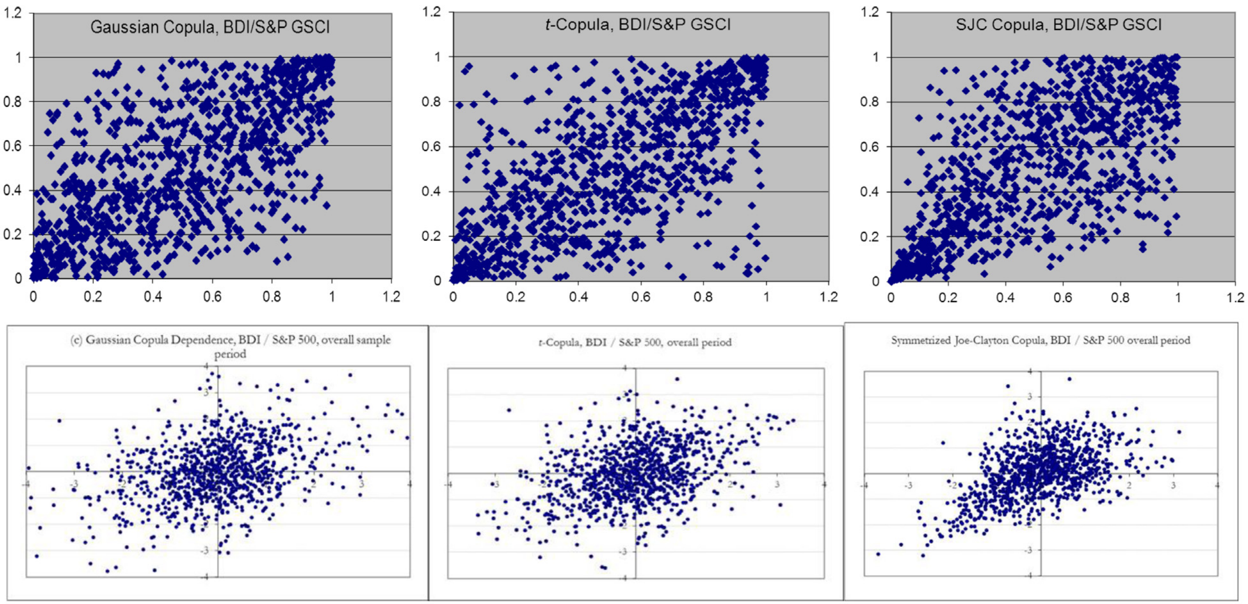

Figure 7.2 Scatterplot for the estimated copula dependence observations for the overall sample. *The dataset has been constructed from Bloomberg and Datastream.*

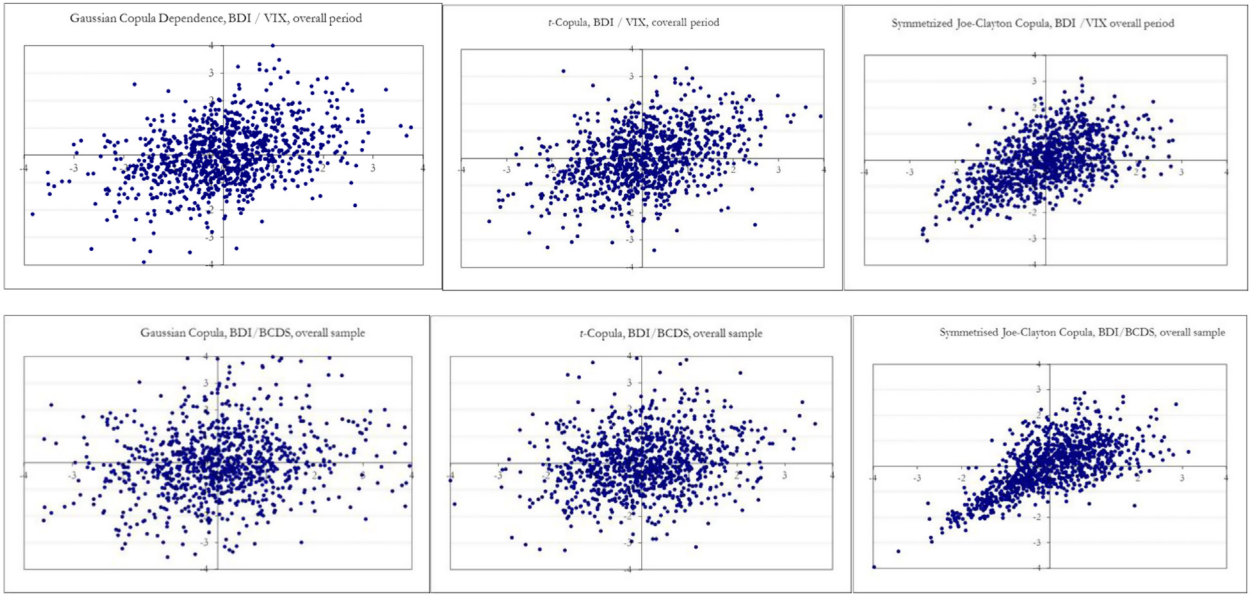

Figure 7.2 (Continued)

Table 7.4 Estimates of copula dependence parameters—crisis period

Variables	Gaussian	Standard error	Student-*t*	Standard error	Symmetrized Joe Clayton	Standard error
BDI/S&P 500	0.248	0.021*	0.267	0.023*	0.221	0.019*
BDI/S&P GSCI	0.254	0.022*	0.280	0.025*	0.226	0.019*
BDI/VIX	0.258	0.022*	0.293	0.027*	0.244	0.021*
BDI/BCDS	0.255	0.022*	0.284	0.026*	0.239	0.020*
BPI/S&P 500	0.219	0.019*	0.234	0.020*	0.215	0.019*
BPI/S&P GSCI	0.225	0.019*	0.238	0.020*	0.221	0.019*
BPI/VIX	0.230	0.020*	0.257	0.022*	0.228	0.019*
BPI/BCDS	0.227	0.020*	0.251	0.022*	0.223	0.019*
BCI/S&P 500	0.229	0.019*	0.258	0.022*	0.226	0.019*
BCI/S&P GSCI	0.233	0.020*	0.262	0.023*	0.237	0.020*
BCI/VIX	0.235	0.020*	0.266	0.023*	0.238	0.020*
BCI/BCDS	0.233	0.020*	0.264	0.023*	0.239	0.020*
BDTI/S&P 500	0.218	0.019*	0.229	0.020*	0.216	0.019*
BDTI/S&P GSCI	0.225	0.019*	0.230	0.020*	0.219	0.019*
BDTI/VIX	0.217	0.019*	0.261	0.023*	0.229	0.020*
BDTI/BCDS	0.216	0.019*	0.232	0.020*	0.220	0.019*

Note: This table presents the estimated copula dependence parameters for the Gaussian, Student-*t,* and Joe Clayton copula functions for the shipping indexes, the financial index S&P 500, the commodity index S&P GSCI, the credit market index iTraxx Senior Financials for Banks' Credit Default Swaps, and the Volatility Index for the crisis period. Asterisk (*) indicates significance of coefficients at the 5% level.

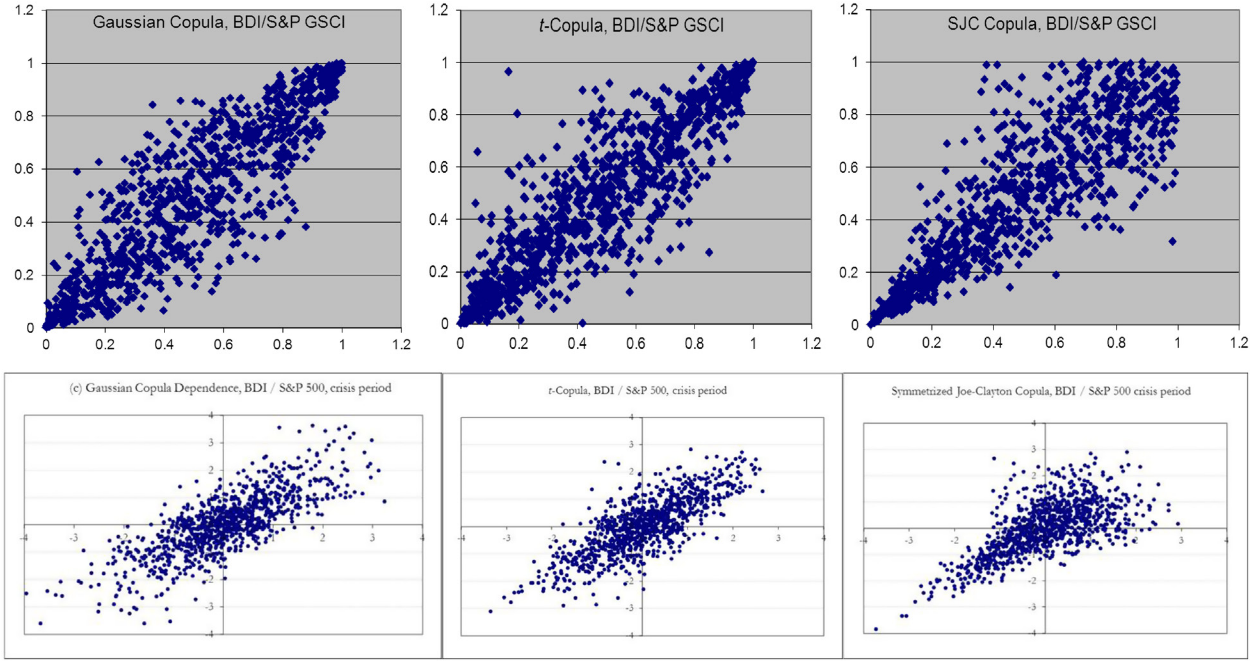

Figure 7.3 Scatterplot for the estimated copula dependence observations for the crisis period. *The dataset has been constructed from Bloomberg and Datastream.*

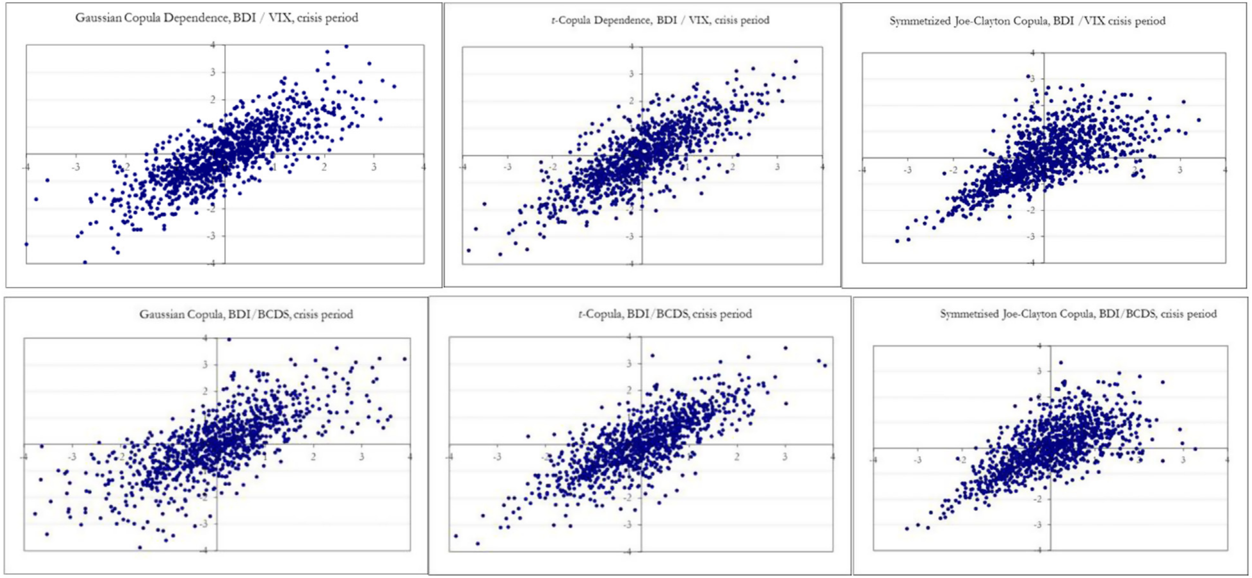

Figure 7.3 (Continued)

and Yuan (2005) who document asymmetric contagion that is stronger during market downturns for international markets. Moreover, the empirical results reported in Table 7.4 document significant and symmetric lower tail dependence during the financial crisis. This finding has important risk and asset pricing implications, since left-tail dependence indicates the potential of simultaneous large losses and higher probability of extreme comovements and contagions, supporting hypothesis 2. Tail dependence implies higher than normal joint risk and, thus, higher value at risk. Furthermore, the existence of joint tail risk alters the pricing of the shipping assets over time.

Again, the dependence for the BDI is higher than the dependence for the BDTI, implying that the Dry Bulk market is more volatile and more vulnerable to downside risks from the Tanker market. Additionally, the dependence for the BCI is higher than the dependence for the BPI, implying that the category of vessels of higher tonnage (i.e., Capesize vessels) is more volatile and susceptible to downside risks than vessels of lower tonnage (i.e., Panamax vessels).

In addition, the results imply that accelerated decreases in the stock market, in the commodity index, and large variations in credit markets (i.e., BCDS and VIX) lead to accelerated decreases and increased fluctuations in the shipping market. Furthermore, during the crisis period the stronger relationship is observed between the shipping indices and the VIX. These findings are also supported by the shipping market dependence profiles in Fig. 7.1, where fluctuations in the shipping indices during the crisis period comove with stock, commodity, and credit markets.

Following Genest, Rémillard, and Beaudoin (2009) we compare the distance of the goodness-of-fit test to select the most appropriate copula function. For this test, the null hypothesis states that the estimated copula provides the best fit to the data for the *P*-values that are higher than the conventional significance level (see also the Appendix, Eqs. (A.3) and (A.4)). The results presented in Table 7.5 and Fig. 7.4 reveal that for all considered pairs, the Student-*t* copula yields the smallest distance for the conducted goodness-of-fit test, indicating that the Gaussian and the Symmetrized Joe Clayton copulas are not sufficient in modeling the tail dependence. As described earlier, the Student-*t* copula assumes asymmetric tail dependence, implying that upper and lower tail dependences are not equal, supporting hypothesis 3. These results are in line with the findings of Aloui et al. (2013) and Patton (2006) who employed copula functions to examine dependence between stock and currencies.

Table 7.5 Distance between empirical and estimated copulas

Variables	Gaussian	*P*-value	Student-*t*	*P*-value	Symmetrized Joe Clayton	*P*-value
BDI/S&P 500	0.053	0.048	0.041	0.043	0.060	0.052*
BDI/S&P GSCI	0.047	0.046	0.032	0.039	0.051	0.045
BDI/VIX	0.095	0.088*	0.058	0.050	0.103	0.091*
BDI/BCDS	0.090	0.087*	0.050	0.049	0.087	0.089*
BPI/S&P 500	0.057	0.050	0.045	0.046	0.065	0.058*
BPI/S&P GSCI	0.054	0.048	0.040	0.044	0.053	0.048
BPI/VIX	0.101	0.090*	0.064	0.058*	0.109	0.093*
BPI/BCDS	0.092	0.088*	0.057	0.050	0.090	0.087*
BCI/S&P 500	0.055	0.049	0.043	0.046	0.062	0.056*
BCI/S&P GSCI	0.051	0.047	0.038	0.043	0.056	0.050
BCI/VIX	0.098	0.089*	0.061	0.056*	0.106	0.092*
BCI/BCDS	0.086	0.084*	0.053	0.049	0.095	0.088*
BDTI/S&P 500	0.058	0.050	0.047	0.048	0.068	0.060*
BDTI/S&P GSCI	0.056	0.049	0.042	0.046	0.054	0.049
BDTI/VIX	0.102	0.091*	0.068	0.060*	0.110	0.095*
BDTI/BCDS	0.090	0.087*	0.060	0.055*	0.099	0.090*

Note: This table displays the distance between the empirical and the estimated copulas according to Cramer—von Mises statistic. A small reported distance from zero, indicates good fit to the data. Asterisk (*) indicates the rejection of the copula model at the 5% level.

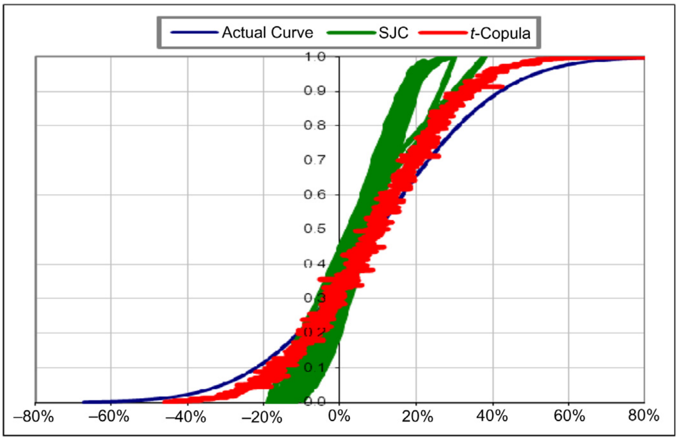

Figure 7.4 Comparison between symmetrized Joe Clayton (bold line starting from −20%) and *t*-copula (bold line starting from −45%) for the model that fits best the data (fine line). *The dataset has been constructed from Bloomberg and Datastream.*

To capture upper and lower tail risks, we compute the tail dependence coefficients implied by the Student-*t* copula which provides the best fit. Our empirical findings reported in Table 7.6 imply that the dependence structure is asymmetric, that is, lower and upper tail dependences are not exactly equal; $\lambda_l \neq \lambda_u$ (see also Fig. 7.5 for a graphical representation). Under symmetry, this difference would be equal or fairly close to zero. However, the Student-*t* copula results suggest that, in the pre- and post-crisis periods, the corresponding appreciation is not experienced with a similar magnitude, given that the shipping market was depreciated heavily during the recent financial crisis and never returned to the precrisis levels. In other words, the shipping market is more dependent at the time of crashing than booming. This indicates the presence of a structural break and a statistically significant decrease in the tail indices after the beginning of the crisis.

In the postcrisis period, the smooth of the upper tail dependence (λ_u) drops systematically, the dynamic of conditional dependence, and the dependence between structures is asymmetric. These findings confirm the comovement patterns documented in Tables 7.3–7.5 and imply that the shipping market experienced a structural break caused by the financial meltdown. In particular, the spread of the financial crisis to the shipping market caused a permanent effect and changed its relationship with the financial, commodity, and credit markets.

Table 7.6 Tail dependence coefficients

Variables	Overall sample		Precrisis period		Crisis period		Postcrisis period	
	λ_l	λ_u	λ_l	λ_u	λ_l	λ_u	λ_l	λ_u
BDI/S&P 500	0.056	0.054	0.032	0.067	0.055	0.039	0.060	0.038
BDI/S&P GSCI	0.058	0.053	0.039	0.067	0.055	0.041	0.062	0.045
BDI/VIX	0.045	0.029	0.026	0.025	0.056	0.080	0.049	0.032
BDI/BCDS	0.038	0.018	0.021	0.023	0.056	0.063	0.044	0.029
BPI/S&P 500	0.053	0.050	0.026	0.058	0.054	0.032	0.055	0.031
BPI/S&P GSCI	0.055	0.051	0.029	0.062	0.055	0.037	0.056	0.033
BPI/VIX	0.043	0.024	0.022	0.011	0.056	0.039	0.037	0.010
BPI/BCDS	0.038	0.016	0.019	0.003	0.056	0.027	0.038	0.015
BCI/S&P 500	0.053	0.050	0.031	0.062	0.055	0.036	0.057	0.035
BCI/S&P GSCI	0.057	0.052	0.034	0.063	0.055	0.040	0.058	0.039
BCI/VIX	0.041	0.028	0.033	0.024	0.056	0.058	0.039	0.020
BCI/BCDS	0.032	0.023	0.020	0.019	0.056	0.042	0.025	0.018
BDTI/S&P 500	0.054	0.050	0.028	0.057	0.055	0.038	0.053	0.039
BDTI/S&P GSCI	0.056	0.052	0.031	0.063	0.056	0.039	0.057	0.040
BDTI/VIX	0.036	0.024	0.022	0.011	0.056	0.053	0.029	0.028
BDTI/BCDS	0.030	0.018	0.019	0.008	0.056	0.041	0.028	0.021

Note: The table presents the upper and lower tail dependence coefficients, estimated by the Student-*t* copula which provides the best fit to the data. Symmetry occurs when the lower tail is equal or fairly closed to the upper tail (i.e., $\lambda_l = \lambda_u$).

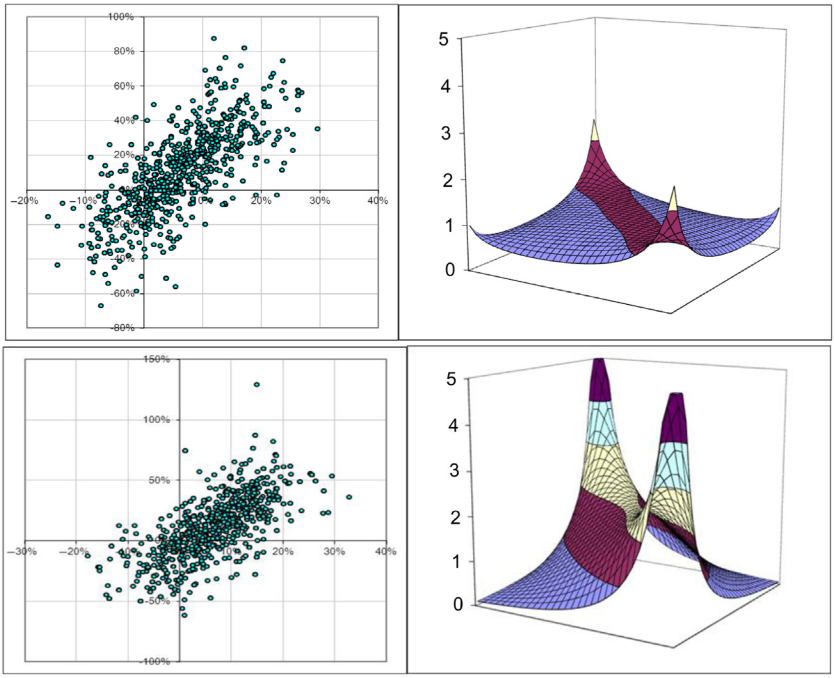

Figure 7.5 Panel A: tail dependence observations for the *t*-copula, BDI, overall sample period. Panel B: tail dependence observations for the *t*-copula, BDI crisis period. *The dataset has been constructed from Bloomberg and Datastream.*

On the other hand, during the crisis period we find evidence of symmetric lower tail dependence. Indeed, λ_l is between 0.55 and 0.56 for all considered pairs. We also note that with respect to the difference between the pre- and postcrisis periods, lower tail dependence increases substantially. This implies that the shipping market becomes more pronouncedly heavy tailed in downward moves than in upward moves. Furthermore, this finding indicates a structural break due to the recent financial crisis that corresponds to the increase in the likelihood of large fluctuations. As a result, in the postcrisis period, the shipping market is more susceptible to crisis episodes and speculative attacks. Significant symmetric lower tail dependence indicates that during periods of shocks and slumps, comovements and contagion from stock, commodity, and credit markets to the shipping market increases significantly. The increased likelihood of extreme joint losses suggests a higher than normal value at risk.

7.5.2 Time-Varying Approach

In order to gain a deeper insight into parameter changes, we follow Aloui et al. (2013) and use a rolling window to examine the dependence parameters of the Student-*t* copula over time. To avoid collinearity issues, we proceed by taking into account only those coefficients that are statistically significant at the 1% level. The parameters of the copula function vary through time following certain evolution equations depending on their previous values. We set the window size fixed and equal to 90 days length, which corresponds to approximately one-quarter of a trading year. Thus the point estimates for the window are *t*-90. We construct a GARCH (1,1) model for each return series and extract the standardized residuals. Then, we apply the empirical cumulative distribution function for the standardized residuals and estimate the Student-*t* copula dependence parameters. In the course of robustness checking, we try out different window sizes (see also Section 7.6 with robustness checks).

We observe that all estimated dependence parameters are not constant over time and exhibit a time variation. Fig. 7.6 shows that the tail dependence between the shipping market and the commodity market increases to a higher level in 2008 while decreases rapidly in the postcrisis period,[4] taking on values between 0.001 (indicating that there is little or no relationship) and 2.000 (indicating a higher probability of joint extreme losses). Moreover, the extreme tail dependence increases to a high level during the period of economic instability in the Eurozone, indicating a rise in the cross-market comovement in 2010.

7.6 ROBUSTNESS CHECK

In order to check the sensitivity of our results, we employ alternative GARCH models and a different rolling window. In particular, (1) we expand the length of the rolling window to 125 trading days—corresponding to approximately 6 months of a trading year—to estimate the time-varying nature of the dependence parameters; (2) we employ a nonlinear extension of GARCH, the exponential GARCH (1,1) model proposed by Nelson (1991); and (3) the fractionally integrated GARCH (1,*d*,1) model proposed by Bollerslev (1986) and Baillie, Bollerslev, and Mikklsen (1996) in order to check for the suitability of our proposed approach.

[4] Similar results are observed for the commodity index and the VIX.

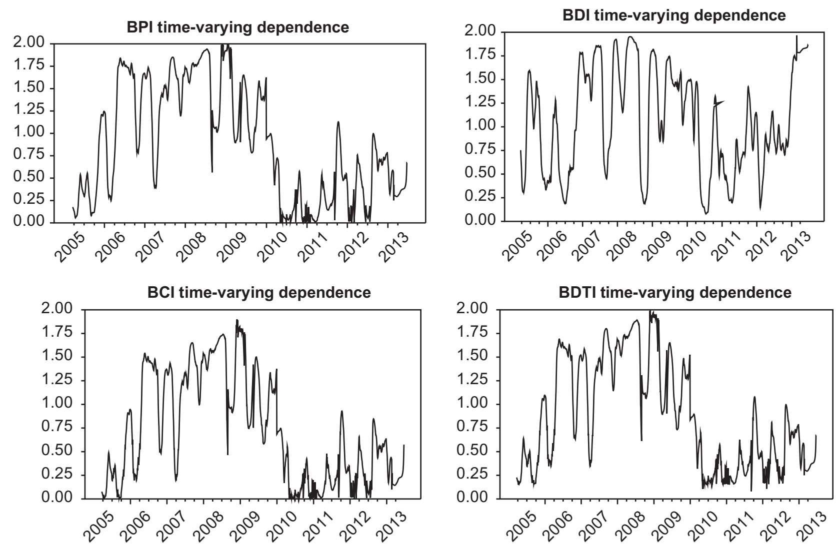

Figure 7.6 Time-varying dependence parameters of Student-*t* copula for the relationship between the shipping indexes and the commodity indexes with one-quarter trading rolling window. *The dataset has been constructed from Bloomberg and Datastream.*

7.6.1 Expanding the Rolling Window

We expect the power of the significance tests to increase with bigger window sizes. However, Fig. 7.7 shows the coefficients to balance themselves so that our conclusions are effectively the same, no matter the length of the window size. Indeed, the obtained results are not different from those of the 90-day rolling window. Again, the dependence parameters are not constant over time, exhibit time-varying patterns and experience a clear tendency of increased comovement during periods of extreme losses. As a result, the forecast horizon does not play a significant role in terms of the level of spillovers.

7.6.2 EGARCH Approach

The EGARCH model allows for testing asymmetries, captures volatility clustering, and leptokurtosis. Indeed, Harris, Kucukozmen, and Yilmaz (2004) employ the skewed generalized Student-*t* EGARCH distribution to capture the skewness and leverage effects into international equity markets. This checking procedure is very important as it allows us to confirm

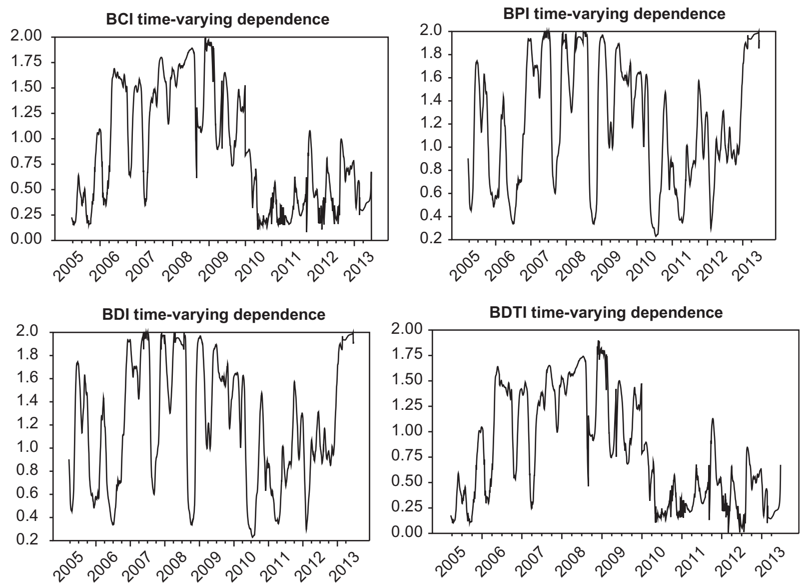

Figure 7.7 Time-varying dependence parameters of Student-*t* copula for the relationship between the shipping indexes and the commodity indexes with 6-month trading rolling window.

the suitability of our proposed approach for modeling the relationships between shipping, financial, commodity, and credit markets.

Table 7.7 presents the results for the dependence coefficients with respect to the EGARCH model. For the overall sample period we observe that there is positive dependence and comovement with the financial and commodity indices, supporting our proposed approach. Again, the strongest relationship is observed between the shipping indices and the commodity index. Positive dependence indicates that a change in the commodity prices is followed by a significant change in the shipping market. Indeed, when economic recovery or expansion takes place, shipping rates tend to soar, as the demand for commodities increases, and more commodities are imported. Thus higher profitability is anticipated from investments in the shipping market. On the other hand, there is a negative dependence structure between the shipping market, changes in the iTraxx Senior Financials Index (BCDS), and changes in the VIX.

However, the pattern of comovement over the crisis period differs from the whole sample. Consistent with our initial results, during the crisis period the dependence increases substantially, implying that negative shocks in the stock market and the commodity index have a stronger

Table 7.7 Estimates of copula dependence coefficients with EGARCH specification

Variables	EGARCH—overall period		EGARCH—crisis period	
	Student-*t* copula	Symmetrized Joe Clayton copula	Student-*t* copula	Symmetrized Joe Clayton copula
BDI/S&P 500	0.156*	0.119*	0.208*	0.190*
BDI/S&P GSCI	0.164*	0.127*	0.229*	0.211*
BDI/VIX	− 0.003	− 0.006	0.251*	0.235*
BDI/BCDS	− 0.004	− 0.004	0.227*	0.223*
BPI/S&P 500	0.128*	0.103*	0.186*	0.144*
BPI/S&P GSCI	0.143*	0.122*	0.203*	0.187*
BPI/VIX	− 0.003	− 0.006	0.247*	0.230*
BPI/BCDS	− 0.003	− 0.005	0.209*	0.195*
BCI/S&P 500	0.140*	0.118*	0.209*	0.193*
BCI/S&P GSCI	0.159*	0.125*	0.264*	0.221*
BCI/VIX	− 0.004	− 0.008	0.281*	0.267*
BCI/BCDS	− 0.005	− 0.007	0.263*	0.228*
BDTI/S&P 500	0.124*	0.101*	0.173*	0.136*
BDTI/S&P GSCI	0.137*	0.115*	0.197*	0.192*
BDTI/VIX	− 0.005	− 0.009	0.231*	0.225*
BDTI/BCDS	− 0.006	− 0.010	0.202*	0.194*

Note: This table presents the estimated Student-*t* and Joe Clayton dependence coefficients using the alternative EGARCH specification. Asterisk (*) indicates significance at the 5% level.

effect on the shipping market. The strongest relationship during the crisis period is observed between the shipping indices and the VIX. During high-volatility periods, where uncertainty increases and credit markets are squeezed, changes in the VIX are followed by changes in the shipping market. The lowest dependence is observed for the BDTI, indicating that the Tanker market is less volatile than the Dry Bulk market.

7.6.3 FIGARCH Approach

The FIGARCH model represents a flexible process for explaining and representing the observed temporal dependencies for the conditional variances. The model allows for long memory (d) in the conditional variance and provides the opportunity to describe the persistency and the structural behavior of the shocks to the shipping market. Table 7.8 presents the results for the dependence coefficients with respect to the FIGARCH model. For the overall sample period, we observe—similar to the results obtained from the EGARCH model—that there is positive dependence

Table 7.8 Estimates of copula dependence coefficients with FIGARCH specification

Variables	FIGARCH (1,*d*,1)—overall period		FIGARCH (1,*d*,1)—crisis period	
	Student-*t* copula	Symmetrized Joe Clayton copula	Student-*t* copula	Symmetrized Joe Clayton copula
BDI/S&P 500	0.132*	0.111*	0.202*	0.184*
BDI/S&P GSCI	0.148*	0.122*	0.225*	0.207*
BDI/VIX	− 0.005	− 0.009	0.244*	0.230*
BDI/BCDS	− 0.006	− 0.011	0.221*	0.212*
BPI/S&P 500	0.111*	0.092*	0.179*	0.141*
BPI/S&P GSCI	0.134*	0.115*	0.195*	0.183*
BPI/VIX	− 0.004	− 0.006	0.238*	0.227*
BPI/BCDS	− 0.006	− 0.010	0.197*	0.184*
BCI/S&P 500	0.136*	0.112*	0.205*	0.188*
BCI/S&P GSCI	0.152*	0.119*	0.259*	0.213*
BCI/VIX	− 0.005	− 0.009	0.272*	0.265*
BCI/BCDS	− 0.006	− 0.012	0.257*	0.204*
BDTI/S&P 500	0.107*	0.091*	0.166*	0.133*
BDTI/S&P GSCI	0.132*	0.110*	0.190*	0.184*
BDTI/VIX	− 0.004	− 0.006	0.228*	0.222*
BDTI/BCDS	− 0.005	− 0.008	0.193*	0.179*

Note: This table presents the estimated Student-*t* and Joe Clayton dependence coefficients using the alternative FIGARCH specification. The long memory process is represented by *d*. Asterisk (*) indicates significance at the 5% level.

and comovement with the financial and commodity indices. The long memory parameter, *d*, is significantly different from zero with high and increasing dependence structure in the crisis period when volatility accelerates, indicating that there is strong evidence of long memory in the returns. The strongest relationship is observed again between the shipping indices and the commodity index. The results also indicate that the *t*-copula function fits best the data. On the other hand, there is a negative dependence structure between the shipping market, changes in the BCDS spread and changes in the VIX.

During the crisis period the dependence increases substantially, implying that negative shocks in the stock market and the commodity index have a stronger effect on the shipping market. Again, the strongest relationship during the crisis period is observed between the shipping indices and the VIX.

Not surprisingly, we also observe that the cross-market comovement is stronger with the Dry Bulk Indices compared to the Tanker Index, indicating that the response of the Dry Bulk market is significantly faster to changes in other markets. Moreover, the results imply that the tail dependence when these markets are booming (upper and right tail) is not the same as when markets are crashing (lower and left tail), indicating a higher probability of extreme comovements (i.e., dependence increases during crisis periods). Consequently, when lower tail dependence increases, comovements increase under severe financial conditions causing asymmetry between upper and lower tails.

7.7 CONCLUDING REMARKS

In this study, we model and examine conditional and tail dependence for the shipping market. In contrast to the majority of the existing empirical literature we employ Gaussian, Joe Clayton, and *t*-copula functions in the shipping indices in order to identify comovements across markets of different asset types. The empirical results imply that: (1) the credit crisis caused accelerated decreases, increased fluctuations, and contagion in the shipping market; (2) tail dependence and contagion are asymmetric, since the variables crash together (i.e., pointing to extreme dependence) but recover independently; and (3) the Dry Bulk market is more volatile and susceptible to downside risks than the Tanker market.

Particularly, we find that the crisis spreads in a domino fashion to the shipping market, over and above what one would expect from economic fundamentals, advancing to contagion. The contagion variables (i.e., stock, commodity, and credit markets) acted as transmission channels and transferred risk to the shipping market. Further results indicate the existence of significant and symmetric lower tail dependences during the financial crisis. We observe changes in the temporal dependence, showing that accelerated decreases in stock markets, commodities, and large variations in credit markets lead to accelerated decreases and increased fluctuations in the shipping market. The significance of the tail dependence implies that these asset classes tend to experience concurrent extreme shocks. Therefore, this study captures the channel and the source which can amplify risks and lead to instability in the shipping market with important hedging, risk, and asset pricing implications.

Moreover, using trading rolling windows we observe that the cross-market dependence increases to a higher level during the financial meltdown, pointing to asymmetric contagion. This is due to the increased contemporaneous dependence of the realized volatility innovations.

Additionally, our results indicate that there is an asymmetry in upward moves for the precrisis period, indicating that markets tend to boom independently. Moreover, we observe that accelerated decreases in commodities and prompt variations in volatility, provoke accelerated decreases and function as a barometer for shipping market fluctuations.

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APPENDIX: ESTIMATION METHOD

We estimate the parameters of the copula using canonical maximum likelihood, which is a semiparametric two-step estimation method. First we estimate the marginals F_X and G_Y nonparametrically via their empirical cumulative distribution functions $F_{\hat{X}}$ and $G_{\hat{X}}$ as:

$$\hat{F}_X(x) = \frac{1}{n}\sum_{(i=1)}^{n}\{1X_i < x\} \text{ and } \hat{G}_Y(y) = \frac{1}{n}\sum_{(i=1)}^{n}\left\{1Y_i < y\right\} \tag{A.1}$$

To ensure that the first condition of the log likelihood function for the joint distribution is well defined, for all finite number of observations n, $\hat{F}_X$ and $\hat{G}_Y$ are rescaled by $\frac{n}{n+1}$.

Following Genest, Ghoudi, and Rivest (1995), we use the CML estimator $\theta_{C\hat{M}L}$ to transform the observations into uniform variates using the empirical cumulative distribution function of each marginal distribution to estimate the unknown parameter θ of the copula as defined below:

$$\theta_{C\hat{M}L} = \arg_\theta \max \sum_{i=1}^{n} Inc(\hat{F}_X(x_i), \hat{F}_Y(y_i); \theta \tag{A.2}$$

Following Genest et al. (2009), in order to compare the copula models we use the goodness-of-fit test based on a comparison of the distance between the estimated and the empirical copulas. Therefore:

$$C_n = \sqrt{n}(C_n - C_{\theta_n}) \tag{A.3}$$

The test statistic considered is based on Cramer–von Mises criterion which indicates that large values of the statistic S_n lead to the rejection of the null hypothesis that the copula C belongs to a class C_0. In particular, the Cramer–von Mises criterion can be defined as:

$$S_n = \int C_n(u)^2 dC_n(u) \tag{A.4}$$

CHAPTER 8

Financing Ships of Innovative Technology

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8.1 INTRODUCTION

The need for examining the financing of technically advanced and of innovative technology tonnage is intertwined with the availability of capital and the terms provided in the market, as well as with the technology that differentiates the current fleet from the new generation of ships.

Traditionally, shipping is financed through syndicated loans. Financing through capital markets in the form of bonds or equity are possible options, suitable or available for a relatively small number of firms, which are also structured and managed as corporations. Partnerships, such as those structured within the German KG[1] or the Norwegian KS[2] framework, have also been extensively used in the recent past, yet most schemes were predominantly leveraged. Therefore, the financial structure boils down to a conventional lending facility. Textbooks, such as that of Stopford (2008), Schinas, Grau, and Johns (2015), and Kavussanos and Visvikis (2016) provide sufficient information and insight on the subject matter.

In recent years, two main developments have blatantly affected the ship finance markets. The first one is the aftermath of the financial and fiscal crisis; since 2008 financing has been difficult to obtain, mainly due to restrictions and limitations related to the banking regulatory framework. In the turbulent years of 2009–11 many assets have been substantially devalued and the exposure of banks was higher than the net-asset value of the underlying assets. This gap resulted in contributions

[1] KG is the abbreviation of a Kommanditgesellschaft and is the German name for a limited partnership business entity mainly used in Germany; more information is available in Johns and Sturm (2015).

[2] KS is the abbreviation of a Kommandittselskap, a partnership under Norwegian Law; von Oldershausen et al. (2015) provide a detailed description of this financial scheme.

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from the cash reserves or from the shareholders, and limited the capacity for financing new projects. In summary, decisions of the past have undermined growth and expansion.

At the same time, most ships had and still have to comply with the emerging environmental regulations. Therefore, the need for fresh capital became acute. This is the second development; due to the requirement for greening operations, new technology has to be installed in both existing ships (to upgrade their systems) and newbuild ships (installed during the build process) in order for the ships to meet the requirements. In both cases, there is a substantial risk associated with the technology and the technical performance of the asset. Along with the environmental requirements, developments such as the arctic passage or automatization, if not the full autonomous operation, of ships pose new challenges. Ships can be classified into two distinct categories: ships of conventional technology that comply with current regulations and serve conventional trades, as well as ships with innovative features, such as liquefied natural gas (LNG)-fueled ones, or ships with extra strength, power and maneuverability for icy passages, or highly automated ones, that satisfy stricter environmental rules or nonconventional trade needs.

Apparently, the literature on regulatory issues, marine technology, and asset financing is vast, yet the specific question on financing innovative and generally nonconventional tonnage has not attracted the interest of researchers except for a few cases. Therefore, the aim of this chapter is to identify the key elements to support decisions and to critically assess some parameters that influence the final result. Methodologically, the argumentation will be conveyed and manifested through comparisons between conventional and new tonnage, and supported by empirical data, such as market statistics and business patterns. Hence, every section of this chapter aims to answer questions that evolve throughout the text. For that reason, Section 8.2 outlines the ship finance market and availability of capital, attempting to cover the supply side of financing. Section 8.3 discusses the premium associated with innovative tonnage. This section addresses issues related to the risk perception and the necessary covenants and concludes with an illustrative market-based example that highlights the revenue differences. It is apparent that the impact of the premium is reflected in the capital expenses (CAPEX) and will be discussed in Section 8.4, as the options of export credit agencies (ExCrA) and leasing will be discussed in Sections 8.4.1 and 8.4.2 respectively. Section 8.5 focuses on the issue of the secondhand market (aftermarket) and considers the experience of single- and double-hull tankers as lessons learned from the past. A liquid aftermarket implies a benefit for the investor that can be somehow quantified and taken into account in the financial plan, while the lack of any aftermarket deprives investors from exit plans. The case of LNG-fueled (Section 8.6.1) ships along with highly automated ships (Section 8.6.2) that relate to reduced operating expenses (OPEX) will be discussed in Section 8.6. These examples are indicative and illustrate the challenges faced. Finally, Section 8.7 summarizes the results and draws useful conclusions.

References and links to literature support the arguments. The familiarity of the reader with the evolution of relevant regulations, along with an understanding of the fundamental cost structure of ship operations as well as of amortized loans, is assumed.

8.2 THE AVAILABILITY OF SHIP FINANCE

The availability of ship finance in the last years has substantially impaired the evolution of the fleet and impacted relevant decisions of both lenders and borrowers. Considering recent statistics, the exposure of banks to ship finance reached a maximum in 2011 (Fig. 8.1). Since 2011, the exposure has drastically declined at a rate of 3.6% year over year and several indices support these findings.

Fresh capital became scarce although not dramatically unavailable. Fig. 8.1 illustrates the loss of appetite for shipping projects from the peak year of 2007, where 128 billion USD, mainly of syndicated loans, were

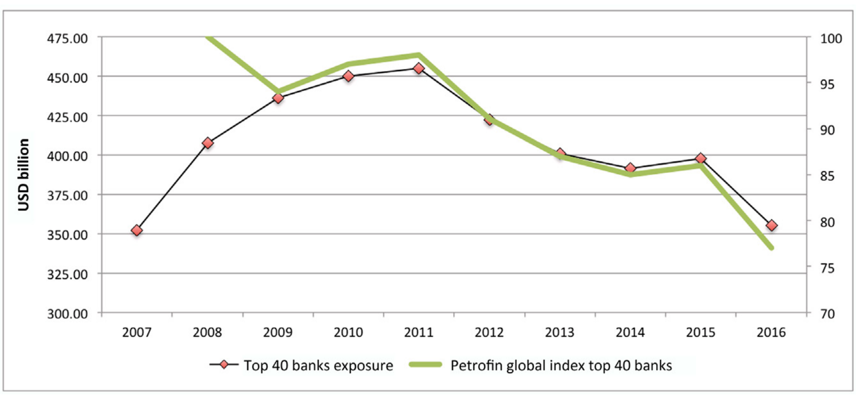

Figure 8.1 Top 40 banks lending to shipping between 2007 and 2016 (Petrofin Global Bank Research, 2017).

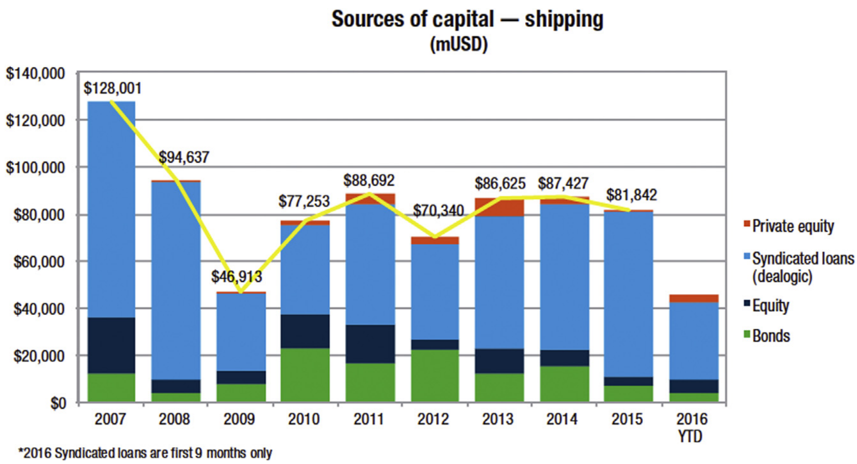

Figure 8.2 Sources of capital between 2007 and 2016 (Petrofin Global Bank Research, 2017). 2016 Syndicated loans are first 9 months only.

poured into the market. In 2009, only 47 billion USD were allocated. In the last years, sums ranging close to 80 billion USD are reported and, as expected, most of them come from the banks. It is interesting to highlight the response of equity markets; in most of these years, the contribution of the public offering is not significant, especially when comparing absolute figures with other industries. Apparently shipping does not attract the interest of investors. However the relative significance of bonds has increased, and the performance of these bond issuances will determine, or at least influence, the perception of the industry and the expected returns in the near future.

Collective works of Schinas et al. (2015) and Kavussanos and Visvikis (2016) provide sufficient information and explanation on the evolution and structure of ship finance markets, and it is out of the scope of this work to address generic issues. However, it is necessary to stress the current lack of capital for new and innovative projects. Fig. 8.2 clearly shows the decline; in such market conditions, projects with a relatively lower risk and yield profile will be considered first for financing. Therefore, projects of companies with higher ratings, i.e., more corporatized companies owning tonnage, as well as more conventional tonnage with the security of long-term employment, such as ships engaged in the transport of energy resources, are more likely to be financed. As long as there is no revenues premium for innovative projects to compensate for the inherent risk premium, these projects require higher equity commitment.

8.3 THE PREMIUM OF INNOVATION

The installation or application of any new technology or device toward compliance with the regulations is associated with a cost that owners will not recover. Due to the global application of the rules, all owners have to comply and generally absorb the cost as it is difficult to pass it over to the users. An exception to this tenet and assumption is the power boosting technologies, such as solar- and wind-related technologies, that reduce consumption and decrease the nominator of the environmental burden in the formula of the energy efficiency design index (EEDI).[3]

The premium of the new technology has an impact on the financial performance of the ship, and the difference in required freight rate (*RFR*) demonstrates the burden of higher initial costs. Based on the examples of Schinas and Kewitsch (2015), Eq. (8.1) illustrates the elements that determine the result. The RFR is the value where the net present value (*NPV*) formula equals zero. The impact of time, i.e., future values, is considered for both revenues and expenses in the formula. Usually, the purchase price (*PP*) of the vessel is fully covered before or at the end of delivery, so it is not further discounted, in contrast to all other streams of expenses and revenues. The revenues part consists of the RFR, the total payload C and the total number of days of employment per annum D_{empl}. The residual value (*RV*) expresses either the price the ship is sold at to new operators or the revenue from demolition at the end of the economic life after N years of employment. In most cases, owners tend to sell ships between the second and third special survey, i.e., between the ages of 10 and 15, as the maintenance and repair costs increase significantly and charters opt for younger tonnage. This aftermarket consideration is important and could also deem the final result of the investment. The last part of the equation is the sum of the *OPEX* discounted over time; OPEX are commonly presented on a daily basis, and owners should cover them throughout the year, i.e., for 365 days. OPEX tend to increase by g every year, a percentage that includes inflation, higher maintenance and repair costs, etc. Finally, the discount factor r reflects the weighted average cost of capital (*WACC*) or inflation or generally a factor that introduces financial pragmatism and features the impact of time. It is apparent that Eq. (8.1) can only be numerically solved, but this is an easy task for modern spreadsheet applications.

[3] See Eq. (8.4).

$$
\begin{aligned}
NPV &= 0 \Rightarrow \\
&\sum_{t=1}^{N} \frac{(Revenues - Expenses)_t}{(r+1)^t} = 0 \Rightarrow \\
&- PP + \underbrace{\sum_{t=1}^{N} \frac{RFR \cdot C \cdot D_{empl}}{(r+1)^t}}_{\text{Revenues}} + \underbrace{\frac{RV}{(r+1)^N}}_{\text{Residual Value}} - \underbrace{\sum_{t=1}^{N} \frac{OPEX_t \cdot 365 \cdot (1+g)^{t-1}}{(r+1)^t}}_{\text{OPEX}} = 0
\end{aligned}
\tag{8.1}
$$

By applying Eq. (8.1) for estimating the RFR of a ship with innovative and of one with conventional technology, denoted by n and c respectively, Eq. (8.2) is derived and results in the difference in RFR that makes a rational decision-maker indifferent. In other words, ΔRFR is the premium in RFR terms that innovative ships should earn in order to yield the same returns. Assuming that both ships are faced with the same OPEX, the final result depends on the original difference of PP, ΔPP, the difference of the final residual value, ΔRV, and the difference of RFR.

$$
\begin{aligned}
\Delta RFR &= 0 \Rightarrow NPV_n - NPV_c = 0 \\
&- \Delta PP + \sum_{t=1}^{N} \frac{\Delta(RFR \cdot C)}{(r+1)^t} + \frac{\Delta RV}{(r+1)^N} + \sum_{t=1}^{N} \frac{\Delta OPEX_t \cdot 365 \cdot (1+g)^{t-1}}{(r+1)^t} = 0 \Rightarrow \\
&\Delta PP = PP_n - PP_c = (RFR_n - RFR_c) \cdot C \cdot D_{empl} \cdot \sum_{t=1}^{N} \frac{1}{(r+1)^t} + \frac{RV_n - RV_c}{(r+1)^N}
\end{aligned}
\tag{8.2}
$$

Should $\Delta RV = 0$, Eq. (8.3) is obtained. The assumption of $\Delta RV = 0$ is a rather soft one, especially when considering the case of demolishing the vessel, as the final price depends on the lightweight of the ship, which is more or less the same for ships of the same size and type. Moreover, the time impact is so severe, either due to the discount factor or the time horizon N or of their combination, where future values are diminished.

$$
\Delta PP = PP_n - PP_c = (RFR_n - RFR_c) \cdot C \cdot D_{empl} \cdot \sum_{t=1}^{N} \frac{1}{(r+1)^t} \tag{8.3}
$$

Considering the results of Eq. (8.3), the willingness of the market to accept a higher RFR, $RFR_n > RFR_c$, is a necessary condition to justify the ΔPP, the purchase premium, otherwise there is no rationale for investing in the new ship. Because of the magnitude, this difference is

Table 8.1 Numerical example

	New	Conventional
Purchase price (mUSD)	48	40
Residual value (mUSD)	9	8
Capacity (tDWT)	120k	120k
Employment days p.a.	340	340
RFR $\left(\frac{\text{USD}}{\text{day}}\right)$	24,464	23,397

substantial. Assume the following simple numerical case of Table 8.1 with 15 years of life span and 10% discount factor.

The indicative and illustrative example yields the following results based on Eq. (8.2): $RFR_n = 24,464\,\frac{\text{USD}}{\text{day}}$ and $RFR_c = 23,397\,\frac{\text{USD}}{\text{day}}$. This difference of 4.56% or almost 500 $\frac{\text{USD}}{\text{day}}$ daily is substantial. Consequently, the investment in new technology should either be envisaged with a daily freight premium the market is willing to pay or to accept reduced profit margins vis-á-vis conventional tonnage.

The above dilemma reflects also the associated risk that could justify the decision of investing in ships with innovative technology. Regulatory changes and associated costs of compliance are identified as risk elements in the literature and definitely considered in business transactions (Schinas & Kewitsch, 2015, p. 50). Assuming an investment in technologies curbing the carbon footprint which aims at satisfying the expected future limits of regulation as in Fig. 8.6, future decisions of the International Maritime Organization (IMO) might deem tonnage obsolete and investments failed. Hence, the sets of risks related to ensuring compliance require assessment and, therefore, diverse approaches to the original investment and choice of technology are expected. When local regulatory initiatives (see also Section 8.6.1), weigh into the decision process, then substantial operational buffers are required as local regulators tend to go beyond what is required by international legislation, i.e., they gold-plate local regulations and distort competition.

So far, there is no clear indication that the market is willing to pay a higher freight rate for greener services. In various market segments, it is possible to have freight rates that apply only for some tonnage, as in the case of ice-classed Aframaxes that usually enjoy a premium over conventional ones. However, this premium is combined with employment and engagement of special interest or attributes. Nevertheless, one could assume that a more efficient ship is generally more attractive to the

Table 8.2 Data for the X82DF-32880kW with nine cylinders of Wärtsilä (p. 83, 2015)

Fuel	Specific consumption	Daily consumption (est.)	Daily costs
	$\frac{gr}{kWh}$	$\frac{tons}{day}$	$\frac{USD}{day}$
HFO	178.9	141.2	34.5k
MDO	178.9	141.2	52.3k
LNG	138.7	109.5	20k
Pilot MDO	1.3	1.0	

users, a hypothesis that is true subject to conditions. When the ship is engaged in the spot market, then a more efficient ship can ask for relatively lower freights, i.e., $RFR_n < RFR_c$ in $\frac{USD}{ton}$ terms, and, therefore, increase employment chances or decrease idle time on an annual base. This could be the case if the running expenses were equal, which is not normally the case. The example of LNG-fueled ships in Section 8.6.1 and especially Table 8.2 elucidate further the conditions. The same applies when the ship is chartered out; in this case the hire of a new technology ship expressed in $\frac{USD}{days}$ should be less than the hire of the conventional one, as the warranty of speed and consumption given by the owners is more appealing to the charterers. Lower consumption at the same speed implies lower voyage expenses and, therefore, higher profit margin for the charterers. This assumption is true only if the benefit gained from the voyage expenses can compensate for the higher running expenses due to the higher PP of the new technology ship. Hence, the touchstone for assessing the financial performance of the asset is the relative gains and burdens, i.e., the compensation of the higher CAPEX with lower operating and voyage expenses, ceteris paribus.

8.4 THE IMPACT ON CAPITAL EXPENSES AND EXPORT CREDIT SCHEMES

It was previously assumed that the PP of the new technology ship is higher than the price of the conventional one. The CAPEX depends largely on the PP and the structure of finance, which boils down to the WACC. A typical plain-vanilla scheme of ship financing involves a portion of equity and a portion of debt (usually via a commercial loan). Depending on the spread and commitments to debtors and equity investors, i.e., agreed terms on return and maturity, WACC is estimated.

The lower the WACC the better, yet it does not always guarantee the interests of both lenders and borrowers. Export credit facilities are exactly attacking at the denominator of Eq. (8.1), while leasing facilities offer financial schemes at higher cost, i.e., higher WACC, and with a different structure and allocation of risks.

8.4.1 Export Credit Agencies

ExCrA are State agencies that provide support to national exporters competing for overseas sales by providing a guarantee or insurance to the benefit of banks financing the export sourced from a specific country. In the maritime context this could be the government agency of the nation where the shipyard is based or of the nation where key equipment manufacturers are based and supply major components for the ship, such as main engine, tanks, propulsion systems, etc. In both cases a meaningful export interest is involved. This insurance or guarantee creates financial collateral that increases the financing prospects of a project and based on which banks can lend funds at lower interest rates compared to plain commercial finance, thus reducing the WACC of the project. Evans and Oye (2001) consider ExCrA as a supporting mechanism, particularly when market failures occur. In addition, Auboin and Meier-Ewert (2003) and empirical research of Manova, Wei, and Zhang (2011) show the positive impact during times of financial crises, when credit market imperfections restrain exports, especially in sectors relying strongly on external finance, such as in the capital-intense case of shipping.

As shown in Fig. 8.1, ship finance banks have significantly reduced their lending activities in the aftermath of the shipping and worldwide financial crisis. In this context the role of ExCrA in ship finance has significantly increased in the post-crisis market and EXCrA involvement has provided an invaluable catalyst to capital allocation in this capital-intensive sector (Gallo, 2014). In relation to the specific case of LNG-fueled engine technology, a review of recent literature has revealed that a key barrier for the application of LNG as a marine fuel is the cost of capital (Rehmatulla, Smith, & Wrobel, 2013; Wang, Faber, Nelissen, Russel, & Amand, 2010). This is exacerbated by the reluctance of commercial lenders to finance environmentally focused investments and technology, which has so far prevented widespread implementation of new technologies or even LNG as a marine fuel (Murphy & Zambrano, 2015). Furthermore, research by Rehmatulla and Smith (2015) has found that market failure exists in relation to the implementation of energy efficiency measures in shipping because of principal agent problems. According to Brown (2001), a market failure implies that the efficient allocation of resources through well-functioning markets is violated. In conclusion, the allocation of capital to finance cleaner fuel technology shows characteristics of market failure, which calls for a more sophisticated financial structuring in order to diversify financing risks and tap additional funding sources.

For analysis purposes a similar approach to the NPV formula, Eqs. (8.1) and (8.2), are used to show that the attractiveness of an investment in general is determined by the cash flows generated from the investment minus the initial investment outlay discounted at the cost of capital. In the specific case of investments in innovative ships, the cash flows (charter payments) as of now are not reflecting the economic and environmental benefits the technology is providing because of market failure (split incentives, principal agent problem). There is no internalization of the external cost so far. Nevertheless, the cash outlay is higher for ships of innovative technology or even for LNG-fueled vessels compared to conventional vessels, as shown in Sections 8.3 and 8.4, thus the advent of new technology is constrained. The novel aspect of the export facilities is no other than a new financing model that is targeting the denominator of the NPV formula, not the nominator, i.e., the associated cash flows. The cost of capital r is broken down into discrete components; each component reflects the cost of capital per source and the implied interest. Fig. 8.3 presents a simplified scheme for the financing

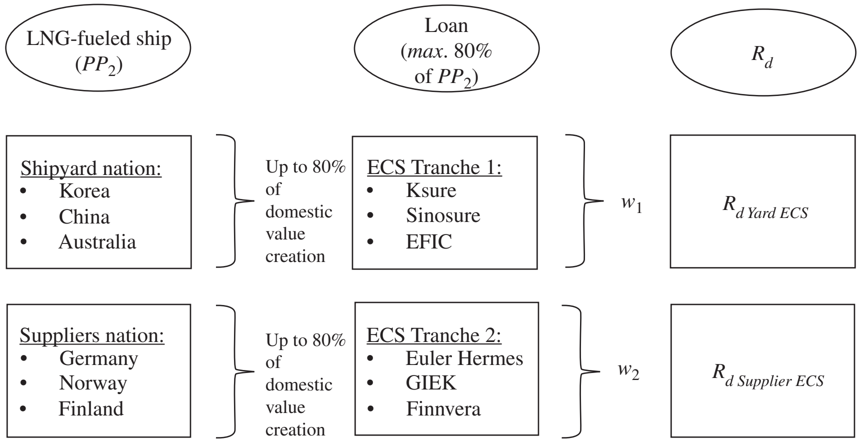

Figure 8.3 Export credit schemes.

of an LNG-fueled ship. In this case, the shipyard nation provides part of the PP through an agency, participating with w_1 weight in the WACC, while a suppliers' nation, such as Germany, provides part of the PP with w_2 weight respectively. The goal is not only to reduce the WACC, but also to provide capital, and level the risk among parties. Focusing on the cost reduction aspect, two conditions are derived that need to be fulfilled:

1. The debt-to-equity-ratio
2. The cost of debt.

The sample structure of Fig. 8.3 reveals the interests and the benefits of the States providing export facilities, as employment, activity, and support of wider interests are supported through asset-based financing. The market effectiveness and efficacy of these instruments depends on their market acceptance and "visibility." That said, it is the shipowner's associated administrative burden and costs that partially determine the attractiveness of such schemes. Financial engineering and innovation demands highly sophisticated decision-making capability and support from all parties involved. Moreover, innovation along other policy objectives can be directly or indirectly promoted through export agencies and facilities. Policy objectives can be integrated into both financial policy tools and other innovative financial structures for targeted investments, such as green technology. These tools and policies aim either at the nominator of the equation, such as subsidized port dues (see Eq. 8.5), or the denominator, such as third-party financing models contributing additional equity or additional financing sources.

8.4.2 Leasing

Clausius (2015) provides a thorough analysis of the leasing schemes in the maritime sector. Moreover he brings forth many insights from the industry that explain or justify the attractiveness of various leasing schemes. Lately, leasing schemes have become popular, as they combine the needs of the shipyards to secure orders and the appetite of investors for an attractive yield on a coupon. Therefore, many diverse leasing schemes and similar combinations have emerged. Leasing could be considered as a possible way to finance tonnage with innovative features, as risks are split among many actors and many wider policies and objectives of the States might be satisfied.

Considering Fig. 8.4 the whole idea is based on a special purpose vehicle (SPV) that will own the vessel and raise the equity and the debt.

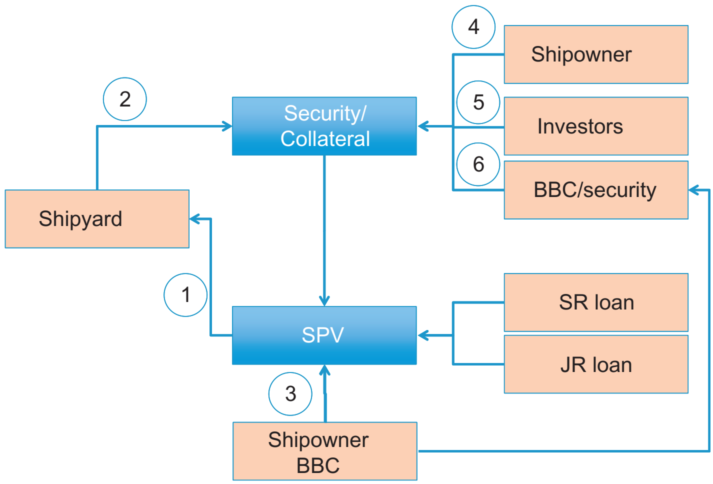

Figure 8.4 A modern leasing scheme.

Investors (5), including the shipowner potentially (4), contribute equity, while debt can fill the financing gap as well as magnify the returns of the equity partners. The SPV orders the vessel from the shipyard (1). Given that the contract between a shipyard and SPV generally requires a substantial amount of the contract price to be paid in advance of the vessel's delivery, the yard provides a refund guarantee, a form of security in respect of those installments. By virtue of the refund guarantee, it is common that a financial institution (i.e., a bank) will support the shipyard by undertaking to back up the obligation. More specifically, in the event the purchaser (i.e., the SPV) ends the building contract for a valid reason (e.g., due to the shipyard's insolvency or not meeting the contracted construction milestones) and the yard for any reason fails to refund the paid installments, the financial institution will refund those installments on the shipyard's behalf (2). Assuming, as commonly practiced, that the SPV has received predelivery financing from a financing institution to finance installments, the SPV will likely be required to assign the refund guarantee as security for the predelivery financing. Any amount that remains after repaying the financial institution may be used to repay the equity investors. Postdelivery, the vessel is offered as collateral for any postdelivery financings. Finally, the vessel is contracted to an "operating" shipowner, the bareboat charterer (BBC), via bareboat charter or lease-back contract, both of which entails clear commercial repayments and terms of hire (3). It should be highlighted that the actual "shipowner" in this scheme is the SPV, not the BBC. In most cases, there is a holding company, a legal conduit that facilitates the interests of the BBC (as operating shipowner) and of the investors (3 $\leftrightarrow$ 4, 5); this entity gets the asset as collateral (6).

Such a financial scheme satisfies the needs of many actors. First of all, a shipowner who does not have sufficient equity or access to financing can be an equity partner and yet retain the ability to operate the ship via the bareboat or lease-back contract. Secondly, the shipyard and the supporting financial institutions in most cases closely related to State interests, secure orders and employment, and at the same time provide asset-backed guarantees at a reasonable cost. Finally, banks usually provide both or either senior or junior loans under market terms, while as equity contributors, the investors enjoy the leveraged returns. In conclusion, all actors should be satisfied at the end. In addition, the final arrangement includes exit points for investors and for the owners, a unique and highly appreciated condition. For example, a commonly considered condition is an option in the contract between the SPV and the shipowner permitting the shipowner the right to acquire the vessel at specific dates in the future at preagreed prices. In such a case, should the market value be higher than the PP, then the shipowner can make a profit by first acquiring the vessel per the agreed terms and conditions and then selling the vessel in the secondhand market.

Nevertheless, the above-mentioned scheme is complex and expensive. The conclusion of the deal might take longer than expected and timing is a critical factor. Besides, the expected returns for the equity investors is normally higher than the cost of debt (generally a 2%—4% premium over senior secured debt (see Section 14.1 in Clausius, 2015), so the WACC is higher. In addition, most leasing schemes come with the onerous "Hell and High Water" clause. The term implies that the lessor (i.e., the shipowner) is required to fulfill its obligations under the agreement regardless of what happens to the vessel. However, this is a condition that could be waived in exchange for agreeing to higher payments, thus resulting in an even higher WACC. The clause is expressed with various different wordings, risks, warranties, and indemnities (see Table 14.2 in Clausius, 2015). In few words, cost and complexity are the two main disadvantages, yet a leasing scheme can relatively effortlessly accommodate export credit facilities, and satisfy the objectives and the needs of more actors. The installation of innovative technologies onboard seagoing vessels also requires assuaging the conflicting goals and interests among all actors and possibly States of "origin" and "installation" of these assemblies or systems.

8.5 THE ISSUE OF THE AFTERMARKET

Considering Eq. (8.2), which relates to the life cycle analysis of conventional versus new technology ships, the importance of $\Delta ResValue$ is emphasized. Should $\Delta ResValue \rightarrow 0$ then the absorption of the original premium throughout the life cycle of the asset depends solely on the extent of a higher freight due to the innovative features. This element of the analysis has also been identified by Faber et al. (2015), which examined LNG-fueled ships and concluded that uncertainty about the secondhand price of LNG-fueled ships is a major barrier to the development of these ships.

So far research on the aftermarket values is practically focused on well-established segments of the market (e.g., in Ådland & Koekebakker, 2004; Kavussanos & Alizadeh, 2002; Sødal, Koekebakker, & Adland, 2009). Briefly, four main factors driving secondhand prices for ships are identified, namely freight rates, age, inflation, and expectations. Apparently, all these factors are presently either undefined or unknown, so any forecast attempt is speculative. However, considering the experience of single- and double-hull tankers, a substantial spread of 4–10 million USD is reported (Fig. 8.5). Without ignoring the fact that the phase out of single-hull tankers resulted from the unilateral initiative of the United States that was adopted later by the international maritime community, and acknowledging the strict enforcement motivation of many States as well as their importance in international trade, it is rather safe to derive the conclusion that this spread is mainly associated with the expectation of the market to further use a secondhand double-hull tanker

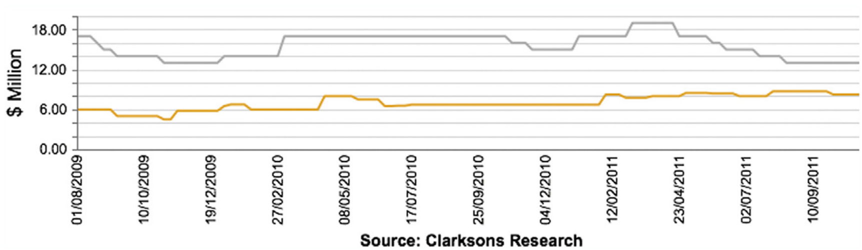

Figure 8.5 Secondhand price spread among single- and double-hull tankers. *Clarksons Research.*

vis-á-vis a single-hull one. So, unless similar conditions apply, i.e., regulatory motivation and enforcement along with the involvement of States with significant impact and footprint in international trade, new technology ships, albeit LNG-fueled or highly automated ones, will not enjoy a premium in the secondhand market. Depressing the potential secondhand market premium further are the incompatibilities and limitations from the technical viewpoint of potential buyers.

8.6 INTERESTING CASES

Following the analysis of the previous sections, the cases of LNG-fueled and of highly automated, even autonomous, ships will be considered. The former have already captured the interest of policy-makers and of researchers. There is substantial, existing information available in the literature and technical reports. The latter are still practically unknown and are largely an undefined problem for the research community. They demand a new risk assessment approach and for that reason a revisit of the fundamentals is required.

8.6.1 The LNG-Fueled Ship

The interest of the academic community as well as of the industry on LNG-fueled ships is sparked from Regulations 19—21 of MARPOL Annex VI, as well as Resolution MEPC.245(66) of 2014, which determine the use of the EEDI, as expressed in Eq. (8.4). Every engine that utilizes fuels consisting of hydrocarbons, such as heavy fuel oil (HFO), marine diesel oil (MDO), and LNG, emits a mixture of carbon oxides, such as carbon monoxide CO and carbon dioxide CO_2.

$$\text{EEDI} = \frac{CO_2 \text{ from the propulsion} + CO_2 \text{ from the auxiliary} - CO_2 \text{ innovative technology}}{\text{DWT} \times \text{speed}} \tag{8.4}$$

The concept behind the EEDI formula (8.4) is to provide a "snapshot" indication of energy efficiency at design conditions, which is based on CO_2 emissions (g) per unit of transport (ton-mile). As per the regulation, the nondimensional conversion factor between fuel consumption and CO_2 emissions C_F ranges from 3.114 to 3.206, depending on the grade of conventional fuel, as per international classification (International Maritime Organization, 2014, paragraph 2.1). This factor implies that for every ton of fuel oil, C_F tons of CO_2 are emitted.

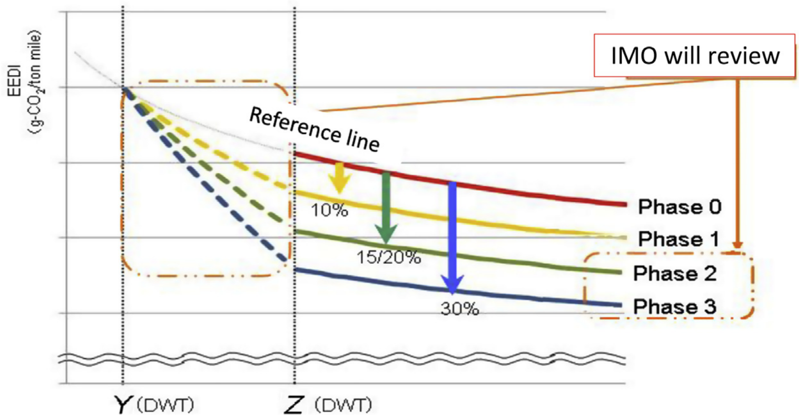

Figure 8.6 Required EEDI against existing and proposed reference lines. *Source: International Maritime Organization (2014), Table 2, Regulation 21, Annex VI, MARPOL (see also Resolution of MEPC.245(66) of 2014 on the Guidelines on the method of calculation of the attained energy efficiency design index (EEDI) for new ships, as amended).*

For every new or existing ship, the EEDI is calculated and measured against the levels provided in Regulation 21 in Fig. 8.6. The estimated EEDI measurement should be below the reference line; otherwise, measures should be taken to reduce the emission of CO_2 per unit of transport, i.e., either to minimize the nominator or to maximize the denominator. As the reference lines will be reviewed by the IMO at the given years, lower reference lines are anticipated in the future, thereby pushing operators to increase the unit energy efficiency of new ships. The use of LNG as a marine fuel with a C_F of 2.75 lowers substantially the estimated EEDI, and also implies compliance with currently expected future reference lines as well.

Many researchers have addressed the issue of LNG as a marine fuel; e.g., Cockett (1997) and Thomson, Corbett, and Winebrake (2015) have examined and considered the technical viability of LNG-fueled ships, Schinas and Butler (2016) examined the differential of fuel prices, Leete, Xu, and Wheeler (2013) analyzed the appetite of investors to support such projects, among many others. At the same time, various policy-makers and stakeholders promote LNG technology (see Andersen, Clausen, & Sames, 2011; DNV GL, 2014, 2015; European Commission, 2012, 2014). Support, however, is not without its criticism: reports based on arguments irrelevant to the marine industry conclude that LNG is a transitional fuel (Council of Economic Advisers, 2014; GasTerra, 2009), while the industry encapsulates criticism on LNG-fueled ships on the basis of the following arguments:

1. LNG bunkering infrastructure
2. Availability of LNG as a fuel

3. Aftermarket of LNG-fueled vessels
4. Regulatory uncertainty.

It is out of the scope of this work to address in detail the above arguments, yet it should be noted that the issue of infrastructure is acute in regions that are not confined by an emission control area, where stricter limits apply for nongreenhouse pollutants, such as sulfur oxides SO_x and nitrogen oxides NO_x. More specifically, it has been decided to make LNG available in the main European ports (European Commission, 2012, 2014), while many terminals in the United States are sufficiently equipped (ABS, 2015). Other sources consider that the lack of availability of LNG as a potential risk is overestimated, and adequacy should be expected in all major hubs (Lloyd's Register, 2014). Furthermore, the results on the price differential given current levels of supply cost can support further the optimism in using LNG as a marine fuel (Schinas & Butler, 2016). The risks of the lack of an aftermarket as well as of the regulatory uncertainty should be further explored, assessed, and addressed.

From a financing point of view, LNG-fueled ships pose new challenges. Using the numerical example of Schinas and Butler (2016), Table 8.3 suggests a substantial reduction of daily costs when using LNG due to lower prices and lower specific consumption. The condition that deems investors indifferent between a conventional and an LNG-fueled ship is derived in Eq. (8.5). This equation considers *CAPEX*, *k* as the premium of the newbuild LNG-fueled ship, *Fuel* as the price of conventional fuels, and *n* as the difference in price of the "greener" fuel used, such as LNG, as a percentage of the price of competing conventional fuels (mainly of HFO), *Port* as the port-related expenses, i.e., the usual port dues related to the ship and not to the cargo, and index 1 applies to the conventional ships (Eq. 8.5). So the discount *m* at ports (in terms of port dues) is derived; it is a compensation paid by the local authorities to

Table 8.3 Numerical example of 1500 TEU slots containership (Schinas & Butler, 2016)

	Conventional		LNG-fueled	
Total	15,400		15,400	
CAPEX	4,500	29%	5,400	35%
OPEX	4,500	29%	4,500	29%
VOYEX	6,400	42%	5,500	36%
Port	*1,600*	25%	*1,420*	26%
Fuel	*4,800*	75%	*4,080*	74%

the ship for polluting less when calling at the port. This is the rational of financial incentives provided by many ports, such as Hamburg, Rotterdam, Singapore, and Seattle, through a reduction of port dues for the greener ships (Hamburg Port Authority, 2013; Mellin & Rydhed, 2011; Merk, 2014; Vinkoert, 2012).

$$m = \frac{k * CAPEX_1 - n * Fuel_1}{Port_1} \tag{8.5}$$

Table 8.3 provides an illustrative example that reveals all risks associated with the financing of LNG-fueled tonnage. Firstly the improved financial performance, and therefore the attractiveness to the charterers, depends heavily on the LNG price. Given the data of Table 8.3, the advantage in daily fuel costs of LNG relative to HFO of 42% can be reduced, if the price of LNG surges and the performance of diesel engines improves. The surge of the cost of LNG is possible due to the new demand, with trends and experiences from the oil industry suggesting that such increases can be expected. Moreover, the further improvement of the thermal efficiency of propulsion plants should be expected too, as there is a substantial drive due to the environmental regulation. So a 20% increase in LNG prices and 10% improvement in terms of specific fuel oil consumption yield an advantage of 20% for the LNG-fueled ship, excluding the higher CAPEX. The impact is clear in Table 8.3: should port dues be at the same level, which is reasonable as not all ports worldwide provide financial incentives, then the advantage of 14% in voyage expenses is lost, and the voyage expenses will be increased by 180 $\frac{\text{USD}}{\text{day}}$ resulting in higher total cost 15,580 $\frac{\text{USD}}{\text{day}}$. Ceteris paribus, such a daily cost structure worries both financiers and owners as the inelastic part of the running expenses is higher. Either the charterer or the owner can impact voyage expenses through slow steaming or other operational decisions, when the market is weak. Therefore, a possible solution for financing LNG-fueled ships is no other than the use of combined export credit facilities, as presented in Section 8.4.1 in order to lower WACC to competitive levels.

8.6.2 Highly Automated and Autonomous Ships

Another aspect of innovation are the highly automated or even autonomous ships. As the scientific field is currently at the early stages of evolution and research assumptions or results are still highly debatable, it is interesting to consider this new generation of seagoing vessels in the analysis. Kretschmann, Burmeister, and Jahn (2017) suggest that unmanned autonomous ships are seen as a key element for a competitive and sustainable European maritime industry. The analysis followed is based on the RFR and determines a benefit of 3.4% lower RFR than of the conventional one for a vessel service life of 25 years. The economic result is justifiably linked with the fuel used and associated with the risk of the technology and of the bunker prices. Rødseth and Burmeister (2015) discuss the associated risks in a rather qualitative approach. Burmeister, Bruhn, Rødseth, and Porathe (2014); Wróbel, Montewka, and Kujala (2017); Wahlström, Hakulinen, Karvonen, and Lindborg (2015) focus on navigation, safety, and the human factor, respectively; currently safety is in the spotlight of researchers today.

Aside from subjective biases and opinions, highly automated and autonomous ships definitely deserve the interest of all stakeholders involved as the main goal is to eliminate or to reduce substantially the OPEX. Highly automated ships satisfy many objectives simultaneously: reduction of the high 50%–60% crew-related costs to total OPEX, a need to improve working conditions onboard and ashore, and an increase in the control level of the ship (a technical and financial asset) as it moves across jurisdictions. Briefly, relevant optimism is justified as current research suggests that this technology is emerging and expected to mature shortly. On the other hand, researchers such as van Hooydonk (2014) remain skeptical, owing to the many potential legal and regulatory concerns. A rough analysis of the Law of the Seas identifies the following articles that need further scrutiny or even amendment in order to accommodate the operation of unmanned vehicles (United Nations, 1982):

1. Art. 27 on the criminal jurisdiction onboard foreign ship
2. Art. 94 on the exercise of jurisdiction onboard
3. Art. 97 on penal jurisdiction in matters of collision or any other incident of navigation
4. Art. 98 on the duty to render assistance
5. Art. 211 on pollution from vessels.

Therefore, concepts such as of *innocent passage*, *rights of Coastal States*, *pollution prevention*, etc. should be revisited. Considering also the current regulatory framework and the provisos of the widely applied English Law, a number of related risks should be addressed and mitigated before considering commercial financing, namely:

1. The role of the master and of the chief engineer
2. Seaworthiness and due diligence with special attention to the ISM Code

3. Security in wider terms than of the International Ship and Port Facility Security (ISPS) Code
4. Liability
5. Navigational errors and avoidance of collision at sea

The discussion is far from a theoretical one and implies a shift from *de lege lata* to *de lege ferenda*. This shift of the legal framework raises the question if Maritime Law is malleable and to what extent. The reason a financier should consider these risks is none other than the validity and the functionality of the usual set of covenants, terms, and conditions considered in the term sheets of newbuilding financing. In conventional ships, most of these risks are known, and sufficiently addressed (see Section 8.3). However, in the case of autonomous ships the liability of the shipyard and of the suppliers should be revisited. Highly automated ships, as well as autonomous ships, imply mass production concepts that enable economy of scale at design and production levels, similar to the levels of aviation or even of land transportation modes. Unless a sufficient number of autonomous and highly automated ships equipped with compatible technologies for navigation and cargo handling is ordered or in operation, the acquisition investment (buyers) as well as the commitment of the shipyard (builders) cannot be justified. Also, the delivery of such ships implies joint design and production effort by the shipyard and the suppliers, so joint warranties and guarantees should also be considered. Moreover, the consideration of export credit facilities or similar schemes for the supply of advanced marine technology might also suggest advanced inter-creditor securities and collateral that increase further the requirement for financial engineering, far beyond the dimension of the WACC. In conclusion, actors, such as ports and suppliers, which are currently not involved in the relationship among buyers, financiers, and builders should be directly connected to the project. Port systems for mooring and cargo handling should be fully compatible with the arrangement and equipment onboard and suppliers should be actively involved in all aspects related to financing, warranties, and guarantees as well as to maintenance and operations, to a larger extent than the current makers' list[4] and practice suggest.

[4] The makers' list contains the possible manufactures of each equipment; the shipyard has the right to choose subject to terms and conditions of the newbuilding contract, see von Ruffin-Zisiadis (2015).

Considering the OPEX levels and the potential benefits for highly automated vessels reported by Kretschmann et al. (2017), it seems that there is no significant difference in the levels from conventional ships. Acknowledging fully the difficulty in assessing the shore-based service facility costs, it is rather safe to consider that OPEX might be structured differently, but the final annual sums will be more or less the same. In spite of that financial aspect, it is expected that the operators of autonomous ships will deploy and apply more sophisticated operational strategies, which can reduce voyage costs, if only the innocent passage conditions hold and the Coastal States do not object to such operations.

Apart from the technical, operational, and regulatory challenges, the era of highly automated and autonomous ships commences and demands innovative financial engineering as well. The cost and complexity of financing depend on the associated risks and the way they are addressed and mitigated. Risks associated with human error and fatigue onboard and ashore, as well as trust and confidence in all aspects, are only some requiring further research and scrutiny.

The requirement of system compatibility, as well as a large fleet of identical vessels in service operating within homogeneous and compatible jurisdictions, suggests corporate financial solutions similar to those considered in industrial shipping. In that sense, transportation services of unitized goods, containers, among ports in the same region might be further considered, requiring the active cooperation of the ports and the close monitoring of the relevant authorities. The involved assets might be optimized for the trade, employed for their whole life cycle yet deprived of aftermarket options. In this case, the cost of energy for moving the assets on prequalified routes will determine the feasibility and success of the project, similarly to pipelines and other transportation systems.

8.7 CONCLUDING REMARKS

The implementation of innovative technology on seagoing vessels is associated with a higher acquisition cost as well as with risks that should be identified or considered anew. As the ship finance markets experience disruptive challenges and the availability of funds is limited, new schemes and financial engineering should be considered. The need for implementing innovation is dictated not only by the expected evolution and trends of the markets and of technology, but also by the strict regulatory framework related to the greening of shipborne operations. Energy efficiency and decarbonization cannot be achieved through conventional technology and means. Therefore, innovative technology should be deployed. Hence financial innovation should be contemplated and the use of export credit facilities or of leasing schemes considered as possible options.

Recent statistics show that the exposure of banks in shipping has drastically declined in the last years. Moreover, the sum of syndicated loans has reduced vis-á-vis the past and other sources of finance remain rather negligible and available to few companies only. In such an environment, less risky projects, i.e., projects with very well-known and secured risks, enjoy a preference. Superficially stated, these projects are backed with long-term employment contracts and low loan-to-value ratios as well as supported by the reputation or capacity of well-established owners and operators. Apart from the inherent risk of innovation, these ships require a higher initial exposure, a cost premium that is translated in a higher RFR than the competing conventional ships. Unless the market is willing to absorb the higher RFR, the owner and/or the operator should absorb the greater costs, thus making the innovative ship less attractive financially. However, it is presumed, and this justifies the risk and the expectation of returns, that regulatory initiatives or fuel prices or even port dues and relevant levies will deem conventional tonnage less competitive if not obsolete. This remains to be seen in the future, although it is highly likely considering the decarbonization requirements of international regulation.

In order to address the need for a higher RFR and the risks, as well as to cope with the limited appetite of financiers, nonconventional financial options should be considered. A possible option is the use of export credit facilities that may lower the WACC of the project to acceptable ranges. This solution implies complexity, as many actors are involved, such as the ExCrA and suppliers and inter-creditor agreements on the securities should be drafted. The availability and the use of export credit facilities are linked with State interests, such as the interests of the technology exporting State. Therefore, these schemes depend heavily on State policies and relationships among States. Another option is the use of leasing schemes. In this case, a higher cost of capital along with interests related to the shipbuilding activity is commonly expected. It is clear that both options can be considered simultaneously or adapted further to meet the needs of a rather large project, as complexity is not paying off in a smaller project. From a financial point of view, the issue of the aftermarket of ships should also be considered. A higher value in the secondhand markets, or even residual value at the end of the economic cycle under consideration, impacts severely upon the financial performance of the project. There is evidence, a historical analogy from the single- and double-hull tankers case, that global regulatory action increases the value of compliant tonnage. Should this be the case with greener and, more generally, tonnage of innovative technology, then these projects enjoy an advantage that could not be ignored.

As greening and innovation go hand-in-hand, the option of using LNG as a marine fuel is a possibility that should be further considered. This option enjoys political support, although it does not fully address the expected decarbonization goals. Moreover, the financial result depends heavily on relative fuel prices, a factor that is beyond the control of the owners, financiers, and operators. Considering the example of LNG-fueled ships, it is possible to consider local, regional, or even wider policies linking the benefit to the environment with discounts at ports and other advantages. The use of export credit facilities and relevant financial perks could be further considered too.

The use of LNG as marine fuel does not disrupt existing business models; it is just an evolutionary step in terms of existing technologies and markets. On the other hand, the use of highly automated or even autonomous ships is disruptive and will definitely impact the relative role and significance of actors and States. The primary objective of automation is to reduce OPEX by diminishing all cost elements related to the crew and the well-being of the crew onboard the vessel. Along with these goals, improved and advanced techniques of routing, greening, cargo handling, etc. could be deployed that finally lower voyage, port, and cargo-handling costs. Nevertheless, there are many legal and regulatory issues that should be clarified and in some cases this implies amendments of underlying policy instruments. Moreover, technical compatibility among the ship, shore, cargo, enforcement, and controlling systems is required. Therefore, the financing of these ships demands the revisiting of fundamental concepts, identification of all risks, and, possibly, employment schemes similar to industrial shipping.

In conclusion, the implementation of technical innovation depends on the available financial innovation. As the market percentage of innovative tonnage increases, many financial solutions will be tested and after a point of maturity some of them will become the new "normal." All these solutions will be examined to the core as the dipole of risk and return governs all relevant decisions.

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CHAPTER 9

Operational and Financial Management in Agricultural Cooperatives

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9.1 DEFINITION, PRINCIPLES, AND FEATURES OF COOPERATIVES

As early as 1844, the first cooperative (co-op), known as "the Rochdale Society of Equitable Pioneers," was founded in Britain on behalf of a group of workers (Evans & Meade, 2005). Now, many co-ops are distributed worldwide in almost every country and every kind of industry, such as consumer goods, producers, services, etc. This section provides an introduction to a co-op's definition, principles, and some specific features in both the operations and financing of co-ops.

All co-ops, regardless of sector or size, operate following a common set of principles that distinguish co-ops from other business organizations. Some general principles are given in Table 9.1.

The earliest principles were proposed by the Rochdale Equitable Pioneers and were known as the "Rochdale Principles," which determine co-ops' unique operating principles and also provided the foundation for the principles on which current co-ops operate. In 1966, the International Cooperative Alliance (ICA) updated the principles, which are now internationally recognized as the "Seven Principles." The ICA also gave a definition that underscores that a co-op is a coalition of a group of people who have the same goals:

> *"A co-op is an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically controlled enterprise."*

In 1997, the United States Department of Agriculture (USDA) adopted just three main principles of user-ownership, user-benefit, and

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Table 9.1 Principles for co-ops

Rochdale principle	ICA principles (international co-op alliance)	US principles
1. Open membership	1. Voluntary and open membership	1. User-ownership
2. One member—one vote	2. Democratic member control	2. User-benefit
3. Cash trading	3. Member economic participation	3. User-control
4. Membership education	4. Autonomy and independence	
5. Political and religious neutrality	5. Education, training, and information	
6. No unusual risk assumption	6. Co-operation among co-ops	
7. Limitation on the number of shares owned	7. Concern for community	
8. Limited interest on investment		
9. Goods sold at regular retail prices		
10. Net margins distributed based on patronage		

user-control (Frederick, Wadsworth, & Eversull, 1997), with the argument that co-ops, particularly agricultural marketing co-ops, cannot follow all principles but must focus on fewer, more representative principles (Ortmann & King, 2007). It gave a definition that directly provides the answer to the question: "who owns, who controls, and who benefits from, the business?"

> *"A co-op is a user-owned and user-controlled business that operates for the benefit of members."*

Evans and Meade (2005), focusing on a study of agricultural co-ops, gave the following definition.

> *"A co-op is an organization in which those who transact with (patronize) the organization also own and formally control the organization, and derive significant benefits from those transactions over and above any financial returns they derive from their investment in the organization."*

This definition highlights an important aspect that distinguishes co-ops from other business organizations: a co-op's equity is invested by

Table 9.2 Co-op glossary

Members/ patrons/users	The users of the services that the co-op offers, e.g., farmers who sell products through co-ops.
Patronage	The quantity or value of business done with the co-op, i.e., the amount of product that farmers supply to the co-op for processing and marketing (e.g., fruit, milk, vegetables, etc.).
Patronage refund	A profit distribution that a co-op pays to its members based on patronage.
IOFs	Investor-owned firms that are owned, controlled, and financed by investors of capital (Hansmann, 1988).
Equity	The amount of the funds contributed by the owners (including subscribed shares and retained earnings).

members and also tied to their economic transactions with the co-op. In addition to different financing methods, co-ops are also distinctive in many other aspects. Table 9.2 provides some terms that are commonly referred to in the literature on co-ops.

Seven key features of co-ops that distinguish them from regular companies or "investor-owned firms" (IOFs) are as follows.

1. Cooperative ownership

Ownership provides the right of control of that enterprise and is also linked to the rights to share a business's net income. In most companies or IOFs, ownership is linked to money invested, and both control and financial rewards are driven by the investment amount. However, co-ops are distinguished from IOFs in that the ownership of the enterprise is linked to members' economic transactions with the organization or what is called patronage (e.g., pallets of fruit or gallons of milk supplied in a season).

2. Cooperative control

IOFs are controlled by shareholders on the basis of one share, one vote. However, the control of a co-op is allocated equally among the users of the co-op following the principle of "one member, one vote," regardless of how much money is invested. In other words, a co-op shareholder cannot enhance his/her voting or power through the acquisition of co-op shares, suggesting a democracy (Duft, 1914).

3. Management organization

Co-ops are businesses owned and controlled by the people who use them; however, it is difficult for member-owners to directly make all the decisions. Co-op management usually has several important elements consisting of member-owners, a board of elected directors, a hired manager, and other paid employees (USDA, 1994). The control is preserved by members electing directors in many of the operations.

4. Objective

Co-ops neither aim to maximize profits as IOFs do, nor pursue zero-profit like nonprofit organizations. As specified in the definition, they are business enterprises that operate for the benefit of members (Lund, 2013). However, benefits may be defined in a myriad of ways: e.g., economic returns, like product payments, or noneconomic benefits, like stability, or growth opportunities. How to measure a co-op's performance in the sense of objectives can be controversial.

The theory that focuses on the distinction between co-ops and other businesses reflects the dual nature of the co-op, i.e., member profit and firm profitability (Soboh, Lansink, Giesen, & Van van Dijk, 2009). Co-ops may show much variation between maximizing member profit and maximizing firm profitability, which depends on the size of business, industry, state of operations, etc.

5. Member equity

In co-ops, the "user—owner" principle not only entitles members to the right of sharing net profits, but it also implies the responsibility of members to make sure the co-op has the capital it needs to operate effectively. One method of investment is through the subscription of co-op shares. However, a co-op's equity is basically limited to its members and tied to members' economic participation. A further explanation of this is given in Section 9.3.

6. Profit distribution

When the co-op earns a net profit at the end of a financial year, the board decides what portion of the net profit is distributed to each member, and what portion remains in the co-op (Fig. 9.1). Note that the net profit is calculated by deducting product payments to members as a cost. The portion that is allocated to members is known as a

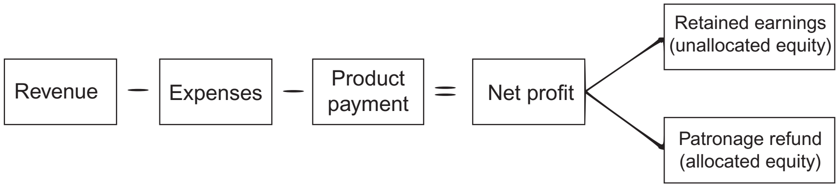

Figure 9.1 Co-op profit distribution.

"patronage refund" or "patronage dividend," which is distributed based upon the members' transactions with the co-op (or patronage), instead of capital investment. For example, if a farmer submits 2% of the co-op's total product in a selling season, then he/she will receive 2% of the annual net profit allocated to member-owners. Using the mechanism of distributing financial return in proportion to patronage is a defining characteristic of the co-op model. The unallocated portion becomes equity that is owned by all members as a whole.

7. Return on equity

In any business enterprise, equity funds are fundamentally at risk because equity holders are the last to be paid when a business suffers bankruptcy or dissolution. IOFs compensate for the risk of equity by distributing dividend payments or changes of share prices; however, co-ops fundamentally differ in that they do not promise particularly high rates of return in exchange for the risk of ownership (Lund, 2013). Also, co-op shares are neither transferable nor appreciable. Instead, the compensation of a co-op is to provide some advantages beyond a simple economic return on invested capital, e.g., a democratically governed business.

Table 9.3 summarizes the above features of co-ops and their differences from IOFs.

It is important to note that, although co-op organizations have been around for a long time, the operating practices and capital structures they utilize need to be evaluated and updated in light of new conditions. The

Table 9.3 Co-ops versus IOFs

	Co-ops	IOFs
Ownership	Members	Capital investors
Control	One member, one vote	One share, one vote
Objective	To meet member's needs	To earn a return on owners' investment
Financial structure	Sales of shares to members	Sales of stock to public shareholders
Equity investment	Patronage associated	None
Distribution of net profit	Based on patronage	Based on capital investment
Return on capital investment	Low	High

next section describes how traditional co-ops have changed their practices in doing business with farmers especially in terms of quality provisions and payment schemes. Then, Section 9.3 introduces co-op finance and how co-ops have innovated their capital structures in response to significant changes in the agricultural economy. Two case studies are presented in Section 9.4. Finally, a brief summary of the whole chapter is given in Section 9.5.

9.2 QUALITY MANAGEMENT AND PRACTICE CHANGES

The purpose of this section is to introduce the challenge of quality coordination in agricultural co-ops. In the economic literature on co-ops, one classical problem of traditional co-ops has been identified as the quantity coordination problem (Albæk & Schultz, 1998). This is because the co-op has no direct control over its input and farmers individually decide how much to deliver to the co-op. The decentralized decision-making of members can lead to both overproduction inefficiencies and free-rider problems (defined later) on quantity. Decentralization also causes the problem of free-riding on quality when the co-op has no quality control over the product supplied by farmers. Compared to the inefficiency of quantity coordination, the problem of quality coordination is considered even more detrimental to the co-op (Pennerstorfer & Weiss, 2012).

The quality of a co-op's product is significantly dependent on the behavior of its members (Baiman, Fischer, & Rajan, 2000). Although it is in the common interest of all its members to deliver products that comply with quality and safety requirements and build up a collective reputation, individually, being focused on their short-term benefit, they might not take these actions (Ostrom, 2014). Some farmers could enjoy the benefit obtained by others who make efforts to improve their quality. Conversely, those who improve the quality would often not be adequately rewarded, causing them to either exit from the co-op or be unwilling to exert effort in the future (Cechin, Bijman, Pascucci, & Omta, 2013). If members just act according to their interests, their behavior may run contrary to the best interests of the integrated entity, and thus set back the sustainable development of the co-op (Harris, Stefanson, & Fulton, 1996). This situation could be further exacerbated when members are highly heterogeneous due to differences in farm size, farm technologies and practices, and even cultural backgrounds. More individual members' goals make collective action more difficult, thus challenging traditional co-op principles (Hovelaque, Duvaleix-Tréguer, & Cordier, 2009).

The changing world provides both opportunities and challenges for co-op quality coordination. Customers are becoming more demanding about food safety and quality, and they are willing to pay a higher price for safety guarantees (Li, Ye, & Yu, 2010). For example, parents in China prefer infant milk formula from New Zealand over and above domestic products, due to New Zealand's high-quality standards (USDA, 2013). In reaction to enhanced competition, co-ops must increase their emphasis on improving the quality of the product. Thus, in the 1990s, many new types of co-ops spread quickly all around the world (Coltrain, 2000). They not only followed some tried and true principles such as those developed and used by traditional co-ops, but also certain new principles that have been developed much more recently (Coltrain, 2000). Both traditional co-ops and new co-ops are member-owned and member-controlled with similar objectives; however, they are quite different in the way they operate and manage the supply and marketing functions.

9.2.1 Quality Provision

The most far-reaching change in co-op management is to specify quality provisions in the contract with farmers. Traditional co-ops usually do not have quality agreements with farmers, and they are expected to find markets for all qualities of the product that are delivered. However, current co-ops usually have specific quality provisions which indicate the characteristics and traits of product that can be delivered (Coltrain, 2000).

Quality and safety guarantees imply less freedom and more control over suppliers' behavior at the farm level (Bijman, Muradian, & Cechin, 2011). To secure the highest quality supply to the market, the effort taken by suppliers is of high importance, since they are the patrons of co-ops (Li et al., 2010). Also, quality control by co-ops is crucial to ensure high-quality products being delivered. Various methods have been implemented in practice, including testing technologies or sampling inspections (Resende-Filho & Hurley, 2012).

9.2.2 Payment Mechanism

The method for paying (i.e., the payment mechanism) rests at the heart of any contract, and it is also the main means for allocating profits/costs and risks and providing incentives. However, a payment mechanism means more than pricing, since it also refers to payment time, payment methods, and so on. In comparison to traditional payment schemes, under which a co-op usually pays a uniform price to farmers at the time of commodity is marketed, a more modern payment mechanism is characterized by the following two aspects: nonuniform pricing and multiperiod payments.

- Nonuniform pricing

  The payment mechanism should be a sufficient incentive to guarantee the participation of suppliers as well as motivation for quality improvement. The traditional practice of uniform payment schemes, under which all farmers receive the same price for their products, is outdated. Instead, many co-ops have resorted to nonuniform payment mechanisms that resemble those used by other regular companies. This is to offer different prices to quality-differentiated products (Fulton et al., 1995). A higher quality product corresponds to a higher price.

- Multiperiod payments

  Another significant difference is reflected in how a co-op distributes payments to farmers. Traditional co-ops pay the spot market price when the commodity is marketed. In contrast, current co-ops adopt multiperiod payment schemes: that is an initial or advanced payment—a price stipulated in the contract is made upon delivery and then one or more progress payments are made based on market returns from the further marketing of products (Coltrain, 2000). Total income is based on the initial payment and progress payments.

9.2.3 Market Strategies

Pooling is a marketing practice distinct to co-ops and refers to a particular method by which each member markets through the co-op to achieve economies of scale (Coltrain, 2000). However, traditional co-ops pool all products to a homogeneous market, which has been proven to be of low-profitability and disadvantageous to success in meeting markets' demands for quality (Saitone & Sexton, 2009). Instead, many current co-ops deliver their products to quality-differentiated markets (Fultion & Sanderson, 2002). Basically, high-quality products are targeted to high-end markets where customers are willing to pay a higher market price.

Table 9.4 summarizes the notable changes introduced in this section. Although the problem of supply chain coordination has been well studied in the literature on co-ops, most papers fail to consider the changes introduced earlier. Therefore, it is quite unclear whether the supply chain can

Table 9.4 Traditional co-ops versus current co-ops

Traditional co-ops	Current co-ops
Without quality provisions	With quality provisions
Uniform payment schemes	Nonuniform payment schemes
One-period payment	Multiple periods payment
Homogeneous market pooling	Quality-differentiated market pooling

be coordinated under these practices. Further, although payment schemes under quality provisions have been addressed extensively in the literature on IOFs, the role of these mechanisms in aligning interests and actions of farmers within co-ops has never been fully explored. One notable exception is in the work of Qian (2017) who, in her PhD dissertation, investigates the quality coordination problem existing in current agricultural co-ops under these changes.

9.3 FINANCIAL MANAGEMENT AND CAPITAL STRUCTURE INNOVATIONS

Like other businesses, co-ops require capital to buy equipment and plant, pay staff, and cover other operating expenses. The money they need will vary depending on the size of the business, stage of operations, and industry. However, they are capital-constrained because of their limited sources of funding. This section provides an introduction to co-op financial sources, financial constraints, and capital structure innovations.

9.3.1 Financial Sources

There are three major sources of funding that traditional co-ops can access as follows:

1. From members

   The "user—owner" principle implies the requirement for a co-op to be capitalized by its members (Li, Jacobs, & Artz, 2014). In practice, members help finance the operations and growth of the co-op in two main ways as follows.

   a. Co-op shares

   A co-op may issue a specific class of stock that is required to be purchased by members as a certificate to join the organization. This type of stock is commonly known as "voting stock" because it is tied to members' voting rights and represents individual member commitment to the co-op. The par value of a co-op share varies greatly from co-op to co-op.

b. Retained patronage refund (allocated equity)

In addition to purchasing co-op shares, another major source of equity is the retained patronage refund. As introduced earlier, the co-op distributes a portion of net income to members as patronage refunds. However, the board also decides what portion of each member's patronage refund will be retained by the co-op for several periods as a source of member equity to finance ongoing operations. The retained patronage refund is recorded in each individual's member account, while the other portion is distributed to members (usually in cash). The general principle of retaining members' designated patronage refunds is based upon their use of the co-op in a proportional method.

2. From co-op business surpluses (unallocated equity)

Another important source of funding is through the retention of business surpluses that are not allocated to members, which is similar to IOFs. As introduced earlier, the co-op retains a portion of net profit as the property of the co-op as a whole. Different from the retained patronage refund, which is a part of allocated equity, this fund of retained earnings becomes unallocated equity that would typically only be divided among members in the case of dissolution. However, the unallocated equity represents a reduced payment to the individual members who willingly accept this reduction only when the benefits it creates for them are clear and worthwhile. The amount of internal co-op capital is largely a result of payments to members in the form of payments for product and patronage refunds (Chaddad & Cook, 2004).

3. From outsiders

In addition to member-provided capital and retained earnings, co-ops often make use of external funds to run a business. External funding may be provided in different ways, and debt instruments are the most common ones, like long-term or short-term loans, etc. Of course, the higher the amount of borrowing, the higher the risk the co-op suffers in the event of inability to repay a loan. Besides, borrowing bears financial costs (i.e., interest payments) that need to be paid eventually.

Determining the type and source of capital is crucial because different sources of capital imply different return and risk. Member-provided equity (co-op shares) is cost-efficient with low return on equity but is resolvable because those shares can be redeemed. Retained earnings are safe and permanent, but may be in conflict with members' expectation on payments. Borrowing is a good strategy only when the returns from borrowing are larger than the cost of borrowing.

9.3.2 Financial Constraints and Problems

The literature argues that one of the weaknesses of the co-op organization lies in its ability to raise capital (Karantininis & Nilsson, 2007). Agricultural co-ops, especially those focused on processing and value-added food systems, are usually subject to financial constraints, which can form major constraints for them to grow and sustain themselves. Chaddad (2006) argues that financial constraints largely result from the incentive mechanism inherent in the organizational structure of co-ops. Several reasons are given as follows:

1. Co-op residual claims are restricted

   Since co-ops are farmer-owned and controlled organizations, co-ops have restricted residual claims (Condon & Vitaliano, 1983). In other words, only active members may provide the co-op with voting equity capital. Therefore, the amount of capital is limited by the number, the wealth, and the risk-bearing capacity of its current members (Chaddad, 2006). Also, co-op residual claim rights, or voting stock, are usually nontransferable. Restrictions on transferability prevents the functioning of a secondary market for co-op shares, and hence leads to portfolio and horizon problems (see later) because members cannot adjust their investment portfolio to match their risk preferences (Jensen & Meckling, 1979).

2. Co-op members do not have appropriate incentives to invest

   In co-ops, there is a very limited return on capital investment because co-ops distribute their earnings by patronage, not invested capital. In addition, co-op shares are nonappreciable. The co-op provides returns to members mainly through farm-gate prices for product and patronage refunds. Therefore, members have an incentive to increase their patronage compared to capital investment (Knoeber & Baumer, 1983).

3. Co-op equity capital is tied to members' patronage

   Co-op equity capital is tied to member patronage in two senses. First, in an IOF, it is not necessary to transact any business with the enterprise to be a shareholder. However, in co-ops, the right of purchasing co-op shares is tied to members' economic participation. Second, traditional co-ops rely primarily on internally generated capital, in particular, retaining patronage refunds. This is because there are few incentives for members to invest in the organization. Therefore, a farmer's decision on transacting with a co-op is tied to his/her decision on investing in the co-op (Peterson et al., 1992).

   However, a co-op's ability to generate internal earnings is constrained by two factors. First, the co-op does not strive to maximize profits as IOFs do; instead, it strives to maximize members' returns especially in the form of product payments. In other words, maximizing members' returns usually requires the co-op to increase the payout to farmers, which hence results in less generated earnings retained in the co-op. Second, co-ops are usually focusing more on low margin than on high margin businesses. Therefore, some economists are concerned that the user—owner principle may hinder a co-op's ability to generate profits (Staatz, 1987). For example, the co-op may have to forego some profitable investment opportunities, whereas the profit-maximizing firms can explore all opportunities for profit (Helmberger, 1966).

4. Co-op equity capital is not permanent

   In traditional co-ops, members provide equity capital through share acquisition or retained patronage refund. However, neither is permanent. Since co-op shares are tied to members' voting rights, they are typically redeemed at par value (original purchase price) by the co-op when a member leaves (Lund, 2013). Furthermore, the retained patronage refunds in the co-op can be viewed as a pool of deferred cash that the co-op temporarily employs and should finally return to individual members (Parliament, Lerman, & Fulton, 1990). In other words, the retained patronage refund recorded in a co-op's balance sheet represents a claim that can be redeemed sooner or later depending on the co-op's plan.

5. Co-ops have limited access to external sources of funds

   Unlike IOFs, co-ops cannot raise money from public shares because their ownerships are restricted to members (Vitaliano, 1980). Furthermore, co-ops also lack access to adequate sources of debt capital, because co-op equity is not sufficiently permanent in the eyes of lenders. Usually, the more equity an organization owns, the more others are willing to lend.

The literature lists some problems resulting from unique co-op organizational structures, which includes the free-rider problem (defined later), horizon problem, portfolio problem, control problem, and influence costs problem (Cook, 1995). These are as follows.

1. Free-rider problem on investment

   The free-rider problem occurs when those who benefit from resources, goods, or services do not pay for them in totality (Olson, 1971). The free-rider problem on investment is likely to occur when new members obtain the same residual rights as existing members and are paid the same price for their patronage. This set of equally distributed rights, combined with nonappreciable shares due to the lack of a secondary market, creates an intergenerational conflict. For example, a farmer may not find it optimal to patronize, and invest in, the co-op until the co-op investment has been undertaken by other individuals. This problem is of particular significance during a co-op's start-up phase, when a co-op relies heavily on direct contribution from members (Giannakas, Fulton, & Sesmero, 2016).

2. Horizon problem

   Cook (1995) summarizes the horizon problem in this way "*The horizon problem occurs when a member's residual claim on the net income generated by the asset is shorter than the productive life of that asset. In a co-op, this problem is due to the nontransferability of residual claimant rights and the lack of a secondary market.*" The general view in the literature indicates that since some members will exit the co-op before they harvest the full benefits from their investment, they are reluctant to invest in co-ops.

3. Portfolio problem

   Another problem associated with members' investment is the so-called portfolio problem. Since co-op equity is nontransferable, nonappreciable, and tied to the patronage, it prevents members from adjusting their portfolios to match their individual risk preferences. Therefore, members hold suboptimal portfolios.

4. Control problem

   The control problem is caused by a divergence of interests between the membership and their representative board of directors and management in a co-op. This problem is also known as the principal–agent problem.

5. Influence costs problem

The influence costs problem is a result of the diverse objectives among its members. When organizational decisions affect the distribution of wealth or benefits among different groups, the affected individual or groups attempt to influence the decisions to their benefit.

9.3.3 Capital Structure Innovations

In response to environmental and structural changes in the food system, agricultural co-ops have adopted a number of competitive strategies, such as value-added processing, branding, global market participation, etc. These strategies require substantial capital investment in contrast to traditional business. To acquire the necessary risk capital to survive in the competitive market, agricultural co-ops are adapting to new conditions and employing organizational innovations.

Chaddad and Cook (2004) summarize several innovative organizational models that have evolved from traditional co-op structure regarding ownership and control rights. They characterize these emerging models by describing various organizational attributes in terms of ownership structure, membership policy, voting rights, governance structures, residual claim rights, profit distribution, etc. In Chaddad and Cook's (2004) typology, five nontraditional co-op models are identified (Fig. 9.2) including "proportional investment co-ops," "member—investor co-ops," "new generation co-ops," "co-ops with capital-seeking companies," and "investor-share co-ops." Among them, ownership rights are restricted to

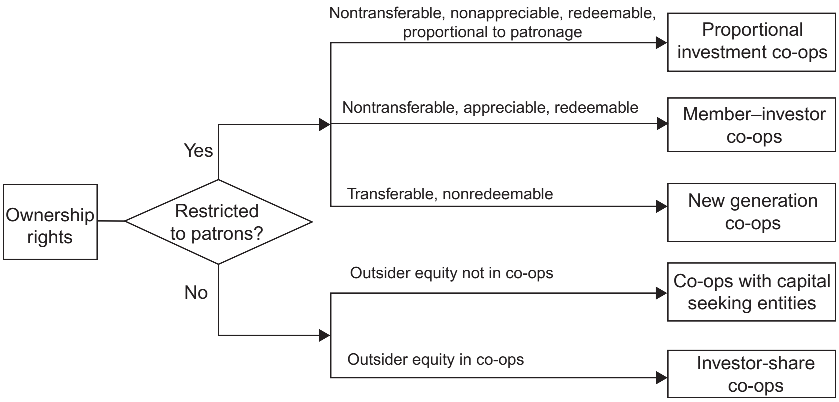

Figure 9.2 Non-traditional cooperative financial models.

member-patrons in the first three model, while not restricted in the last two models. The following provides a brief description of them all.

1. Proportional investment co-ops
   a. Co-op ownership is restricted to members.
   b. Co-op shares are nontransferable, nonappreciable, and redeemable.
   c. Members are required to invest in the co-op in proportion to patronage.
   d. Profit is distributed in proportion to patronage.

   Proportional investment co-ops need to adopt equity management policies to ensure proportionality of equity, and a commonly adopted management tool is known as the *base capital plan* which is implemented as follows:
   a. Choose a base period, which may vary from 1 to 10 years.
   b. Determine a measurement unit. For example, a ton of fruit or a hundred-weight of milk.
   c. Determine the investment level according to each member's patronage. For example, if a member's average patronage over the base period accounts for 15% of total patronage, then his investment level shall be 15% of total investment accordingly.
   d. Identify overinvested members and underinvested members, and making equity adjustments to achieve proportionality.

2. Member—investor co-ops
   a. Co-op ownerships are restricted to members.
   b. Co-op equity is nontransferable, redeemable, and appreciable.
   c. Profit is distributed in proportion to member shareholdings rather than patronage.

   In this model, the co-op may distribute cash dividends in proportion to member shares or set a policy allowing the appreciability of member shares. When residual claims are appreciable, members have more incentives to invest in the co-op.

3. New generation co-ops
   a. Co-op ownerships are restricted to members.
   b. Co-op shares are nonredeemable but transferable.
   c. Profit is distributed in proportion to patronage in addition to shareholdings.

   In this model, ownership rights are in the form of tradable and appreciable delivery rights restricted to current member-patrons. The transferability provides liquidity and capital appreciation through secondary market valuation. Also, member-patrons are required to acquire delivery rights on the basis of expected patronage such that usage and capital investment are perfectly aligned.

4. Co-ops with capital-seeking entities

   This model relaxes the restriction that co-op ownership is restricted to member-patrons. Outside equity capital is purchased by a separate legal entity like strategic alliance, a trust company, or a publicly held subsidiary.

5. Investor-share co-ops

   This model issues separate classes of equity shares in addition to the traditional co-op ownership rights held by member-patrons. Investor shares may bundle different ownership rights in terms of returns, risk bearing, control, redeemability, and transferability, including preferred stock, nonvoting common stock, and participation certificates, etc. However, investor shares usually do not carry voting rights in the co-op.

The structures described earlier suggest that agricultural co-ops are increasingly relaxing some of the structural constraints imposed by the traditional model, hence financial constraints are ameliorated. However, under those transformations, new organizational costs may surface. Members may have to share profits and control rights with outside investors who are not necessarily patrons of the co-op and thus may have diverging interests. Conflicting goals between maximizing returns to investors and maximizing returns to member-patrons may occur as a result.

9.4 NEW ZEALAND AGRICULTURAL CO-OPS

New Zealand is famous for its advanced agricultural industry and prominent products all over the world. Co-ops and other forms of farmer-controlled business are major players in some agricultural sectors, which together account for a significant share of the economic activity of the country. A recent study of United Nations in 2014, which looked at the social and economic impact of co-ops, ranked New Zealand first out of 145 countries and indicated it to be the world's most co-op economy (http://www.un.org/esa/socdev/documents/2014/coopsegm/grace.pdf). This section introduces the New Zealand Kiwifruit Industry under Zespri International Ltd and New Zealand Dairy Industry under Fonterra Cooperative Group Ltd.

9.4.1 Zespri

Zespri is a consumer-driven, 100% grower-owned company dedicated to the global marketing of kiwifruit (https://www.Zespri.com). Not only a leading kiwifruit pioneer, it is also the sole exporter of New Zealand kiwifruit outside of New Zealand and Australia. To counteract the power of overseas buyers, the New Zealand government established producer boards with "single desk selling" provisions that enabled them to be the sole marketer and export distributor of their product. Currently, Zespri is comprised of almost 3000 domestic and international growers and is the biggest marketer of kiwifruit in the world, with over 30% of market share. As a growers' organization, Zespri takes responsibility for a large range of activities from collecting kiwifruit from growers, storing them in inventory, transport and shipping, marketing promotion, research, and so forth. While not formally a co-op, Zespri is operated for the benefit of its growers.

Kiwifruit thrives in New Zealand's temperate climate and thus enjoyed significant cost advantages over other farmers for most of the 1980s. However, when the kiwifruit industry was first developed in New Zealand, it confronted great challenges from its domestic competition as well as competition from Italy and Chile. Oversupply and undercutting of price led to the collapse of this industry in international markets. Also New Zealand failed to differentiate their product from Chilean and Italian counterparts with the common product name "kiwifruit." Under the concern of high risks, heavy fixed and variable costs, long-term investment, and being at the mercy of consumer demand and climatic conditions, the New Zealand Kiwifruit Industry was a price taker rather than a price maker in export markets (Crocombe, Enright, & Porter, 1991). In response to these problems, kiwifruit growers in New Zealand raised their hands and signed an agreement to form a coalition, developing a new structure with an exclusive brand name: Zespri. The strategy of being "customer-driven" marks it out as a premium product, moving it from the category of a perishable commodity into the premium-priced consumer goods bracket. Key attributes of the Zespri structure are as follows:

- Quality provision

  Zespri has a specialized requirement regarding quality attributes as they find that increasingly consumers are prepared to pay more for better quality fruit. Considering the quality attributes of kiwifruit, this refers mainly to the size and taste of the fruit, which is tested by the

Taste Zespri program through a sampling methodology that calculates the Taste Zespri Grade by examining the dry matter content. Using this methodology, only fruit that meets the basic quality requirements are delivered to inventory and then separated into several categories according to quality and variety.

- Quality premium

  In general, growers are paid on the number of trays they supply to Zespri. However, as well as a base fruit payment, there are some premiums that act as commercial incentives to encourage the supply of fruit demonstrating a range of product specifications in demand by customers. Like most co-ops, Zespri does not pay growers by individual slot, and payments are often pooled at an entity level to disperse the risk and maintain a greater orientation to the end market.

- Multiperiod payments

  The payments of Zespri can be split into two types: an "advance payment" and "progress payments."

  - The advance payment is paid at the time the packhouse submits the growers' fruit into Zespri's inventory. This payment could vary due to the volume submitted as well as incentive premiums for quality, service, and time, which encourage growers to supply and deliver kiwifruit with characteristics that benefit customers as well as growers.
  - Progress payments are made monthly from the start to the end of the season and are discretionary based on market returns. Although fruit is pooled in the market, it is categorized by the degree of quality and variety. Generally, high-quality fruit brings more market returns than low-quality fruit.

- Market strategy

  Zespri differentiates markets by exporting high-quality fruit to global markets like Japan while pooling low-quality fruit to the local markets. Further, Zespri has either separate sales pools or a combined sales pool. For example, Zespri has separate sales pools for GREEN and GREEN ORGANIC Kiwifruit; while it has a combined sales pool for GOLD and GOLD ORGANIC Kiwifruit.

9.4.2 Fonterra

Fonterra is owned by around 10,500 New Zealand farmers and collects approximately 85% of New Zealand's milk production. It is also New

Zealand largest company and is responsible for 30% of the world's dairy exports. Its core business consists of exporting dairy products, which accounts for 95% of its New Zealand production, and a fast-moving consumer goods business for dairy products; it produces over 1000 dairy-based ingredient products for the international food industry under the NZMP brand (www.fonterra.com). In New Zealand, dairy marketing has gone from some competing co-ops to one dominated by a single co-op in a short period. The primary motivations for the creation of Fonterra were to achieve cost savings and provide a more effective platform to compete in international markets.

Fonterra restructured its capital structure in 2009, although it was never a traditional co-op in both operations and capital structure since its launch in 2001. Table 9.5 summarizes Fonterra's capital structure features before 2009 and is sourced from Trechter, McGregor, and Murray-Prior (2003).

The old capital structure mitigated many classic problems that existed in traditional co-ops, like free-rider issues on investment because of the proportional requirement between capital investment and milk

Table 9.5 Fonterra's old capital structure

1	Fonterra is a user-owned, user-controlled, and user-benefit business.
2	The voting rights are based on the amount of milk delivered rather than one person—one vote.
3	There is a contractual relationship between Fonterra and its milk producers. Fonterra requires its farmers to match their shareholding with their milk production by owning one co-op share for each kilogram of milksolids produced annually. However, there is no real penalty if the farmer provides less milk than his shares due to unexpected conditions.
4	The capital investment is limited to farmer suppliers, restricted from public shareholders.
5	The dominance of Fonterra in the New Zealand dairy industry requires it to, generally, accept any new suppliers.
6	The operating income is distributed based upon milk production.
7	Fonterra is obligated to redeem shares when production drops or issue shares when production increases.
8	Fonterra's stock is transferable but only to the co-op itself.
9	The amount of a farmer's initial investment depends on the amount of milk estimated and the fair market value of Fonterra's shares. The share price is determined by an independent valuer. The valuation reflects Fonterra's profit expectations and hence varies year by year.

production (Trechter et al., 2003). However, like most co-ops who are striving to compete in global markets, the most pressing issue for Fonterra was to source sufficient equity capital. The previous capital structure stipulated that co-op shares were limited to farmers only, and also required that farmers matched their shareholding with their milk production in proportion. Therefore, if farmers' milk production dropped in any season, Fonterra had to redeem shares to ensure the proportionality. Consequently, Fonterra faced the risk of losing large amounts of share capital through redemption during times of declining milk production. For instance, after milk production fell during the 2007/08 drought, Fonterra had to pay out $742 million of share capital to farmers via redemptions.

To deal with those problems, the board of Fonterra announced a 2-year consultation program regarding their capital restructuring option in 2007, namely putting the business operations in a separate listed company, but maintaining the control within farmers. However, the proposals encountered significant opposition from both Farmer Shareholders and the government, which had to pass enabling legislation, because farmers were very worried about the risk of losing control, in what was described as demutualization. After continuing consultation with Farmer Shareholders, in 2009, the board announced a three-step process to revamp Fonterra's capital structure, which abandoned thoughts of a public listing of Fonterra shares but retained 100% farmer control and ownership. Now the new capital structure is characterized by the following features, as summarized in Table 9.6.

1. Three-year rolling average standard

   The Share Standard that the number of shares a Farmer Shareholder is required to hold in accordance with the patronage is

Table 9.6 The comparison between Fonterra old and new capital structure

Old capital structure	New capital structure
In proportion to last year milk production	In proportion to 3-year average
No flexibility on the Share Standard	With flexibility on the Share Standard
Shares are nontransferable among farmers	Shares are transferable among farmers
Restricted from outsider investors	Issuing Units to outsider investors
Milk-based profit distribution	Equity-based profit distribution

calculated based on a 3-year rolling average of a farm's milk production. A new member is required to invest based on an estimation of average milk production. This is designed to smooth out seasonal production fluctuations and reduce the need to buy or sell shares in any season.

2. Flexible share requirement

Fonterra gives farmers greater flexibility in the number of shares they can own. Farmers are allowed to hold more or fewer shares, than required by the Share Standard, to an extent which Fonterra permits. However, voting rights remain based on share-backed milksolids, just like before.

3. Fonterra Shareholders' Market (FSM)

The Fonterra Shareholders' Market is a private market on which only Farmer Shareholders (or specially appointed markets) are allowed to trade shares. In other words, Fonterra enables the transferability of its stock, not only to itself but among farmers. Since there is no need to directly trade with farmers in shares, this provides Fonterra with a permanent share capital regardless of any individual changes in milk production in any season.

4. Fonterra Shareholders' Fund (FSF)

This fund is set up to financially help farmers purchase or sell shares. Outsider investors who are not allowed to hold shares in Fonterra can invest in Units in the Fund, which are listed on the NZX Main Board (https://www.nzx.com/markets/NZZX). For example, a Farmer Shareholder can sell his shares to the Fund based upon his milk production or personal risk preferences. The Fund pays Farmer Shareholders for the economic rights of shares (receiving dividends and the gain/loss from any changes in share values), not voting rights.

5. Fluctuating share price

With the launch of "Trading Among Farmers" consisting of FSM and FSF, the share price is no longer valued by an independent valuer who had determined the share price of Fonterra for the next season based on Fonterra's estimated market value in the future. The share price, like other freely traded public shares, is now driven by what Farmer Shareholders trade at.

6. Dividend distribution

As a financial incentive for farmers to hold more shares than production, Fonterra distributes any profits (after farm-gate milk payments) as a dividend based on shares held, rather than milksolids produced.

9.5 SUMMARY AND FUTURE RESEARCH

This chapter provides some background information on co-ops. It first clarifies co-ops' unique features. Then Section 9.2 investigates the quality coordination problem for a co-op and provides an overview of co-ops' operational practices and quality management. Next, Section 9.3 introduces cooperative finance and various capital structures. Finally, two New Zealand case studies, namely Zespri and Fonterra, are introduced in Section 9.4.

There are many worthwhile opportunities for future research in both operations and finance management of co-ops. One attractive direction is to construct theoretical models for co-ops who motivate members to invest more than they are required by patronage via several financial strategies, e.g., issuing preferred stock. In this case, the coordination of members' role as patrons and as investors needs to be carefully considered. Another extension is to consider the involvement of outside investors via issuing preferred stock or common stock. It awaits further investigation to see how to motivate outside investors without compromising the benefits of members. Last, but not least, it is worthwhile to model farmers' incentives in both production and capital investment in response to co-ops' financial strategies and capital structure innovations.

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CHAPTER 10

Cold-Chain Systems in China and Value-Chain Analysis

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10.1 INTRODUCTION

People are looking for new supply sources of quality raw materials such as agricultural products and fresh foods. Advanced cold-chain logistics is required to meet consumers' increasing demand for quality chilled and frozen food. A cold-chain has cold-storage warehouse facilities, cooling operation, and logistics services to maintain the quality of local and imported chilled and frozen food and its products and to ensure them be distributed in time to various points to meet consumers' needs.

As the international trade of agricultural products becomes fully global, the public is becoming increasingly concerned about food safety, food hygiene, and the reliability of the food supply system. For example, the 2008 melamine contamination of milk in China caused six infant deaths and stirred a public outcry about the country's food safety system. As melamine contamination spread to different milk brands and milk-containing food manufactured by different producers, imports and sales of Chinese dairy products were banned by over 10 countries (Chan & Lai, 2009). The vaccine scandal in 2016, involving illegal vaccines worth nearly $90 million that had been sold in at least 24 provinces since 2011, caused public panic across China (Wang & Burkitt, 2016). The vaccine produced in Shandong province in eastern China was not stored and transported in the required cold-chain conditions; thus patients taking the ineffective vaccine could suffer severe side effects or even death. Concerns were raised on food and medicine safety regulations and on the transport conditions and traceability along the global supply chain.

China has a huge consumer population for agricultural products, and currently accounts for about 60% of the world's total vegetable production, 30% of fruit and meat production, and 40% of eggs

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and aquatic products. Every year there are about 400 million tons of agricultural products in circulation (Zhiyan Research, 2016). However, cold-chain supply for perishable products has not kept up with the rapidly expanding market. Temperature-sensitive biopharmaceutical products also require cold-chain supply. However, at present, the biopharmaceutical cold-chain monitoring system scarcely exists in China. Li, Li, and Shuo (2008) discussed the "broken cold-chain" problem in the transportation of products from the pharmaceutical manufacturing factory to patients. Temperature-sensitive products arrive damaged or degraded because of a broken cold chain, which arises from problems concerning management and regulation mechanisms. Rossetti and Handfield (2011) reviewed the radical changes of biopharmaceutical supply chains and identified the major drivers of associated management. Obviously, both the perishable food and biopharmaceutical markets are in urgent need of improved cold-chain systems to ensure the quality and safety of products during the distribution process.

According to the definition by the Global Cold Chain Alliance, "cold chain" refers to the management of the temperature of perishable products in order to maintain quality and safety from the point of slaughter or harvest through the distribution chain to the final consumer. Research on cold-chain issues can be categorized into four topic areas: (1) operations in the cold chain (e.g., production, distribution, storage, and inventory); (2) policy and legislation (e.g., some related standards such as HACCP, ISO22000, and GMP); (3) management (e.g., supply chain coordination, quality management, revenue management, and performance evaluation); and (4) technology (e.g., tracing technology and temperature control).

The cold-chain system is a type of supply chain system whose core requirement is a low-temperature environment that maintains the quality of perishable products. The cold-chain system has a representative supply chain structure with a close relationship to the requirement of temperature. In contrast to a general supply chain system, the cold-chain system has three "T" requirements, namely "time," "temperature," and "tolerance." The quality of refrigerated products decreases over time. In warm temperatures (20–60°C), the growth rate of some microorganisms, for example, doubles for each 3°C rise in temperature (Cengel & Ghajar, 2011). The temperature and time constraints define the complexity of the cold-chain system compared with general supply chain systems.

Time-perishable products require a higher level of coordination in the processes that operate along the stages of a cold-chain system.

This chapter attempts to extend the concept of value chain to build a framework for the cold-chain value system of perishable product markets. We focus on the supply systems of the cold-chain industry and attempt to identify how the performance of the cold-chain can be improved from the supplier relationships. The remainder of the chapter is organized as follows. Cold-chain market demands are explored in detail in Section 10.2. The relevant research of the value-chain system is introduced and applied to the cold-chain industry in Section 10.3, followed by an examination of China's cold-chain system in Section 10.4. On the basis of an analysis of demand and supply, some implications for the cold-chain industry in China are identified and discussed in Section 10.5. Section 10.6 concludes the chapter.

10.2 OVERVIEW OF COLD-CHAIN MARKETS AND SUPPLY CHAIN CHALLENGES

The cold chain is a supply chain with temperature control. The type of cold chain is categorized by the temperature requirements of the products involved. Maheshwar (2008) classified refrigerated cargoes as food or non-food items and as chilled cargoes and frozen cargoes according to the storage environment. Chilled cargoes, also known as perishable cargoes, are stored above −10°C. Correspondingly, frozen cargoes are stored under −10°C, usually under −18°C (European Council Directive, 1989). In practice, the cold-chain industry is usually differentiated into three categories: fresh agricultural products, frozen processed products, and pharmaceutical products (given in Table 10.1), which each have

Table 10.1 Categories of cold-chain products

Category	Temperature requirement	Product specification
Fresh agricultural products	0–20°C	Vegetables, fruits; meat, poultry, eggs; aquatic products, horticultural products
Frozen processed products	~ −18°C (< −15°C)	Frozen foods, poultry, and other packaging cooked food; ice-cream and dairy products; fast-food raw materials
Biopharmaceutical products	2–8°C	Vaccine, antibiotics, biological products, and food products

different temperature requirements. Fresh agricultural products vary from 0°C to 20°C, biopharmaceutical products need strict temperature control between 2°C and 8°C, and frozen processed products must be around −18°C and not higher than −15°C.

To illustrate the current status of cold-chain markets in China, we specifically analyze three categories in turn below by introducing the current market capacity and distribution, the requirements of the cold-chain system, and a summary of the existing problems and challenges.

10.2.1 Fresh Agricultural Products

Fresh agricultural products comprise fruit, vegetables, meat, milk, and dairy products. From 2008 to 2014, China's agricultural products in the cold-chain market experienced an annual growth of 35%, reaching 1.6 trillion RMB in 2014. Domestic meat consumption in 2001 of 61 million tons increased to over 87 million tons in 2014. Fig. 10.1 illustrates the

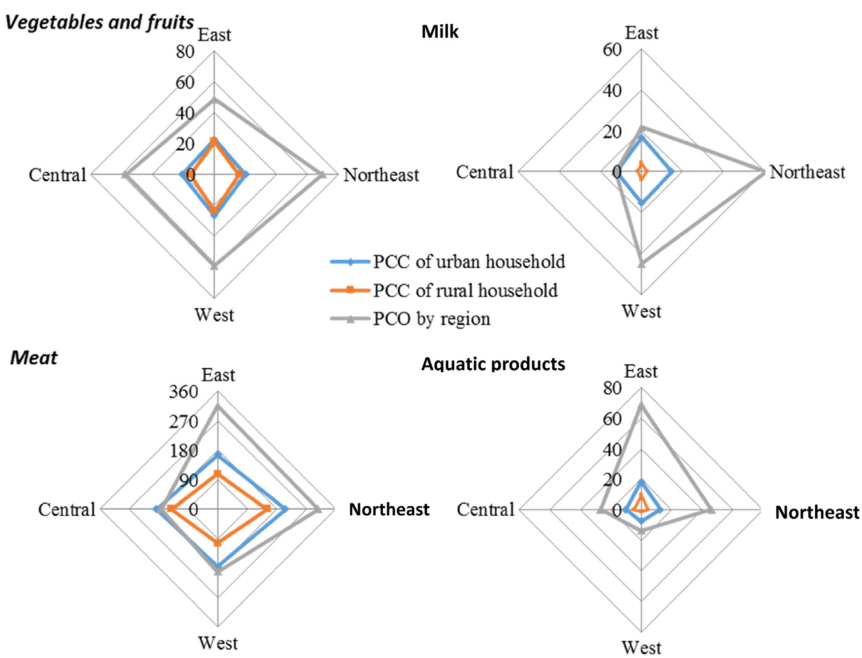

Figure 10.1 Distributions of PCC (kg/year) and PCO (kg/year) of agricultural products.
Directions refer to generalized geographical regions of China. *Data are compiled from China Statistical Yearbook 2015.*

per capita demand (unit: per capita consumption, or PCC) and supply (unit: per capita output, or PCO) of each niche agricultural product market in the four regions of China. The vegetable and fruit market is relatively balanced in demand and supply. In contrast, the milk market is quite imbalanced as the output is mainly from China's western and northeastern regions, but the more developed eastern region has higher consumption. Thus, milk products need cross-regional transportation and distribution from the western and northeastern regions to the eastern region cities. In general, China logistics system is undergoing regionalization (Liu, Wang, & Yip, 2013).

Different cold-chain products have distinct supply systems and may thus have specific requirements for processing, transportation, and storage. However, they all require uninterrupted temperature control and quick delivery. Moreover, fresh agricultural products are necessities for peoples' daily lives and have a steady demand. Therefore, the circulation of fresh agricultural products is often on a large scale with a low-elasticity demand. For these reasons, fresh agricultural products require a safe, efficient, and robust cold-chain system.

According to statistics from Cold Chain Logistics Committee under China Federation of Logistics & Purchasing, in 2015, the rates of refrigerated transportation and storage for fruit and vegetables, meat, and aquatic foods under the whole cold-chain condition in China were 22%, 34%, and 41%, respectively. In contrast, the rate of circulation of perishables under cold-chain conditions in Europe and North America was over 95%. The rates of loss of fruit and vegetables, meat, and aquatic foods during the logistics process in China were as much as 15%, 8%, and 10%, while that in developed countries was less than 5%, and only 2% the United States (Ding, 2010). The high rate of loss of fresh agricultural products in China is due to the dispersed and small size of farm supply, incomplete refrigeration facilities, a lack of professionalized logistics services, and poor organization of circulation. For example, one critical process in the cold chain is precooling, which restrains the respiration of fresh agricultural products to avoid decomposition. Precooling requires investment into dedicated cold-chain facilities, but owners of small farms cannot afford such investment for fresh agricultural products. Moreover, the wide geographical distribution of supply sources for products such as milk aggravates the difficulties of achieving fast delivery.

10.2.2 Frozen Processed Products

National Bureau of Statistics data show that between 2006 and 2014, the output value of China's frozen-food industry attained an annual growth rate of 21%, reaching 71.5 billion RMB, thereby becoming the fastest-growing food industry subsector. Statistics from the China Beverage Industry Association indicated that national cold beverage production reached 25.4 million tons in 2012, with an average annual growth of 16% from 2002 to 2012. Seasonal variations in the consumption of ice-cream and dairy products have gradually disappeared.

Quick-frozen products and ice-cream and dairy products are temperature controlled at $-18^{\circ}C$ or below. The temperature must be stable and maintained at all points within products, but may fluctuate briefly upward by no more than $3^{\circ}C$ during transportation.

10.2.3 Biopharmaceutical Products

Biopharmaceuticals include products such as medical drugs, vaccines, blood products, and interferons. China's biopharmaceutical industry has undergone recent rapid development. The total industry output value was only 15.8 billion RMB in 2002, but had reached over 134.6 billion RMB in 2012 (China Pharmaceutical Yearbook, 2012). Taking vaccines as an example, the outbreak of the SARS (severe acute respiratory syndrome) epidemic in 2003 stimulated the demand for flu vaccine in China: the consumption of flu vaccine was no more than 5 million doses in 2002, whereas more than 15 million doses were administered in 2004 (Yi, Zhang, Wang, Li, & Wang, 2009), which further increased to more than 40 million in 2015.

Biopharmaceutical products are very sensitive to temperature and have the strictest temperature requirements of between $2^{\circ}C$ and $8^{\circ}C$. Biopharmaceuticals are sensitive biological substances and are subject to loss of potency with time (Gazmararian et al., 2002). They must be stored properly from the time of their production until the time that they are used to treat patients. Exposure to either excessive heat or cold will result in loss of potency. To maintain product quality, all biopharmaceuticals must be stored continuously at the appropriate temperature during the whole process from production to consumption. The guidelines "*Good Distribution Practices (GDP) for Pharmaceutical Products*" by the World Health Organization in 2010 show that the distribution process has not been properly emphasized regarding the "establishment, development, maintenance, and control over the activities involved." A further complication of the shipment of biopharmaceutical products is that they are often transported in a multibatch, small-lot pattern, but require fast delivery.

10.2.4 Problems and Challenges

The time-perishable and vulnerable features of refrigerated products commonly require an uninterrupted control of temperature and quick delivery. The China Supply Chain Council conducted a survey of 378 logistics executives involved in the transportation and storage of temperature-controlled goods (Fig. 10.2). The survey revealed that the two most frequently encountered problems in the cold-chain supply in China were the quality of service and the quality of transport. The results showed that the key areas where cold-chain service providers could improve, as recognized by most companies, were those of service processes and cost-effectiveness. Management, equipment quality, and lead-time were also considered to be important aspects. Price, range of services, and service levels were identified as being the most important criteria when companies select a cold-chain service provider.

Table 10.2 illustrates the distribution costs and gross profit ratios of cold-chain markets in China. Although all the average gross profit ratios of refrigerated product industries are relatively high, especially that of the biopharmaceutical sector, the high distribution costs account for a considerable share of sales revenue.

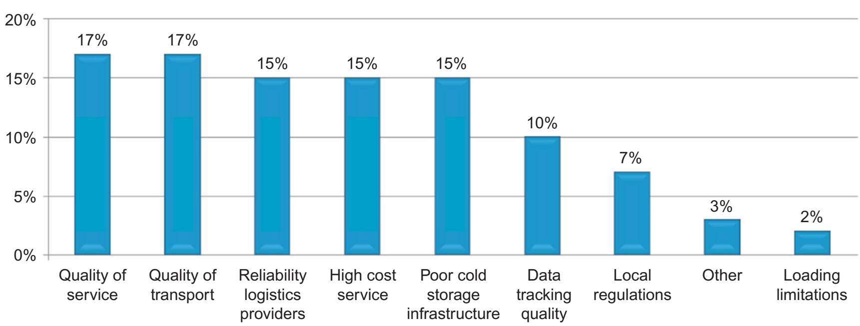

Figure 10.2 Main problems of the cold chain in China. *Compiled from the survey by China Supply Chain Council in 2006.*

Table 10.2 Distribution costs and gross profit ratios of cold-chain markets in China (2009)

Items	Fresh agricultural products (milk and dairy only)	Frozen processed products	Biopharmaceutical products
Number of enterprises	812	301	768
Total profit from sales revenue (RMB billion)[(1)]	33.026	4.522	22.719
Total selling and distribution cost (RMB billion)[(2)]	19.416	1.679	5.619
Average gross profit ratio (%)	23.5	16.9	30.6
Ratio of distribution cost to sales profit (%)[(3)]	58.8	37.1	24.7

Compiled from Global Economic *Data*, Indicators, Charts & Forecasts (CEIC) China Database; (3) = (2)/(1).

10.3 PERISHABLE PRODUCTS, COLD-CHAIN SYSTEM, AND VALUE CHAIN ANALYSIS

Previous studies on perishable products (e.g., Beilock, 1981; Pasternack, 1985) focused on specific segments such as transportation problems and pricing strategies. With the increasing public awareness of food quality and drug safety, the traditionally fragmented perishable product markets have undergone rapid structural changes in the last two decades. The trend in research interests has now shifted to quality control, product traceability and supervision, and coordination in the entire cold chain. Study showed that food safety measures in developed countries have a strong impact on export-oriented supply chains in developed countries (Henson, Brouder, & Mitullah, 2000). Cold chain is changing from a system dominated by producers/exporters (often run by government bodies and producer groups) feeding products into traders and wholesalers toward a system dominated by end-customers (Drewry Shipping Consultants, 2003). Research also focused on the increasing importance of biopharmaceutical cold-chain management as a result of the growing market, the requirements for storage and distribution, the monitoring of temperature, and regulatory trends (Bishara, 2006). It was also found that the need for appropriate equipment to store and transport vaccines in developing countries led to innovations in refrigeration equipment as well as adoption of high-performance vaccine cold boxes and carriers (Lloyd & Cheyne, 2017).

Generally, there are two categories of study that address this new issue regarding perishable products, the research on cold chains and supply relationship, and the research of value-chain analysis. In terms of the cold supply chains, an analytical model of product quality and supply configurations was developed with an optimal batch size of storage, and addressed the energy and environmental concerns of cold chains (Zanoni & Zavanella, 2012). The survey of the industry experts' insights about European food service supply chains showed that the industry is aiming at creating customer value (Darkow, Foerster, & von der Gracht, 2015). The cold chains of aquatic products were also discussed and it was shown that within certain temperature range, lower temperature brings higher profit level, and their findings encouraged better temperature control of cold chains (Wu, Deng, Zhang, & Zhang, 2015). One type of cold chains, i.e., the pharmaceutical supply chain was studied with a systematic review of research on managerial issues, and the research direction about structure of pharmaceutical supply chains was highlighted (Narayana, Pati, & Vrat, 2014). Regarding the vaccine cold-chain system, three key issues were identified limiting this cold-chain system through experiment studies in 10 countries, i.e., insufficient cold-chain capacity, lack of optimal equipment or technology, and inadequate temperature monitoring and maintenance (Ashok, Brison, & Letallec, 2017).

The goal of supply chain management (SCM) is the creation of both value and satisfaction for customers and the improvement in the competitive advantage of supply chain partners (Cooper, Lambert, & Pagh, 1997; Langley & Holcomb, 1992; Mentzer et al., 2001). The implementation of SCM requires the integration of processes from sourcing, to manufacturing, and to distribution across the supply chain. Four critical elements of supply chain strategy that impact the achievement of supply chain integration and performance consist of strategy vision, insourcing—outsourcing strategy, supply chain segmentation and architecture design, and product and service design.

The insourcing—outsourcing strategy manages outsourced operations to establish core competencies and maintain competitive advantages. It links closely to the firm's strategic vision and the ways in which value can be created for customers. Supply chain architecture addresses the design of both the physical structure and conceptual structure of the supply chain. It is necessary to meet specific customer needs at the required service levels. It has been found that Chinese third-party logistics providers' customer orientation significantly influences improvements in customer–firm logistics (Tian, Ellinger, & Chen, 2010). In addition, it was also been addressed that opportunistic behavior by buyers could reduce incentives for private investment in cold-chain infrastructure, but that long-term commitment by chain partners would strengthen the potential for private markets to provide cold-chain services (Salin & Nayga Jr., 2003).

The strategic perspective on SCM emerges from Porter's theory of value chain and value system. Porter (2001) used the terms "value chain" and "value system" to discuss company strategies in terms of the management of relationships with other firms. The value chain describes the full range of activities involved in forming a product or service from conception, through the different phases of production, and delivery to end users. The value system basically extends the idea of the value chain to interlink organizational value chains (Kaplinsky & Morris, 2001). Value-chain analysis is a powerful tool for strategic planning as it allows the value generated along the chain to be scrutinized to increase profit margin. By exploiting the upstream and downstream information flowing along the value chain, firms may try to bypass intermediaries, create better business models, or make improvements in their value-creation system. Nevertheless, it is worth noting that the profitability of segments changes over time and with changes in business environment. Also, customer value theory indicates that what customers value changes over time (Flint & Mentzer, 2000; Woodruff, 1997). Therefore, it is critical to understand the dynamics of the value-chain system.

The recent research of value-chain analysis has been extended to material flows and supply chains. For instance, the methodology of value-chain analysis was used to study the combination of material flow analysis of the UK aluminum sector with a consideration of the economic dimension of those material flows (Dahlström & Ekins, 2007). Besides, a conceptual model for the scrap tire reverse supply chain was proposed and the value-chain analysis method was applied to the scrap tire reverse supply chain (de Souza & D'Agosto, 2013). It was also shown that establishing nutrient cycles may solve the problem of efficient management of nutrients and lead to innovative added-value chains with a higher added-value (Maaß, Grundmann, & Und Polach, 2014). The material flow and value-chain analysis method was used to quantitatively analyze the value flow of iron resources in China (Yan & Wang, 2014).

10.4 SUPPLY CHAIN INTEGRATION STRATEGY OF THE COLD-CHAIN SYSTEM

10.4.1 Value Chain View of the Cold-Chain System

From the perspective of the value chain, cold chains (or cold supply chains) are a series of value-adding activities that occur under temperature control. The cold-chain system is a combination of primary activities, from material supply to the sale of products with the management of temperature, and supporting activities include technology, infrastructure, information and finance, and human resources. Fig. 10.3 illustrates the value-chain system of the cold-chain industry. Similar to general supply chains, a typical cold chain consists of raw material suppliers, manufacturers, distributor retailers, and third-party logistics providers. In contrast to general supply chains, technologies are especially critical to the cold-chain industry as the cold-chain system integrates advanced refrigerated and frozen equipment and technology, dynamic temperature-tracking and monitoring technologies, and developed logistics technology.

The center of the system is the product flow, beginning from raw material supplies to the finished products entering the consumption stage. The value-added activities along the cold chain can be decomposed into seven primary activities, namely materials supply, manufacture, process, storage, transportation, distribution, and sales. The bottom layer in Fig. 10.3 specifies the primary activities. The success of the flow of products along the cold chain requires close cooperation among suppliers, manufacturers, logistics service providers, and dealers. A single enterprise can perform one, several, or even all of the primary activities.

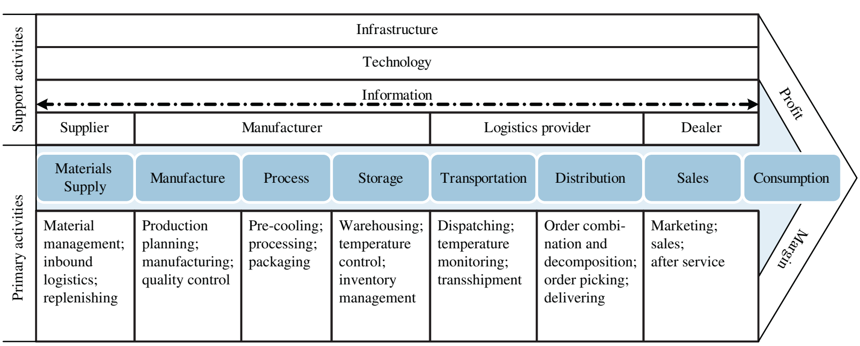

Figure 10.3 Value-chain system of the cold-chain industry.

Process adds value to products by maintaining product quality along supply chains. In the door-to-door delivery process, refrigerated products should be packaged under controlled temperature conditions, not exposed to heat, and prevented from variations in temperature. Storage generates time value by solving the temporal mismatch between demand and production. Transportation creates value by solving the spatial mismatch of demand and production. In the cold-chain system, temperature fluctuation is the major reason for deterioration in product quality, whereas transportation is the most difficult aspect regarding the maintenance of steady, low temperatures during the passage of the product from the manufacturing factory to end-customers. The transportation of refrigerated cargoes differs from that of general cargoes because it needs efficient refrigerated transportation, maintenance of refrigerated storage, and an integrated cold chain to preserve the quality of foods/products. Good, timely distribution increases product value through meeting consumers' diverse demands. Sales create value through facilitating consumers.

The biopharmaceuticals industry has a relatively long value chain, comprising research and development (R&D), clinical trials, production, distribution, and sales. The pattern of value creation in the biopharmaceuticals value chains is "u-shaped," whereby high levels of profit are concentrated in the upstream R&D and in the downstream sales.

A comprehensive value-chain analysis can determine the profitability of activities and identify the allocation of profit along the value chain. Such an analysis can also help to focus on the core business and, more importantly, to take effective measures impacting the upstream and downstream operations in order to maximize the profit. As the profitability of segments can change both over time and with changes in the business environment, firms should also select a supply chain strategy in accordance with the market structure.

10.4.2 Analysis of the Supply Chain Structure

Fig. 10.4 illustrates some typical supply chain structures of the cold-chain industry in China.

Manufacturers in the fresh agricultural food supply chain (second column of Fig. 10.4) are farmers, who, although numerous, generally operate at a small scale and have no market power in China. The upward suppliers are the seed and feed producers, and the traditional downward retailers are the supermarkets and grocery stores. Raw agricultural

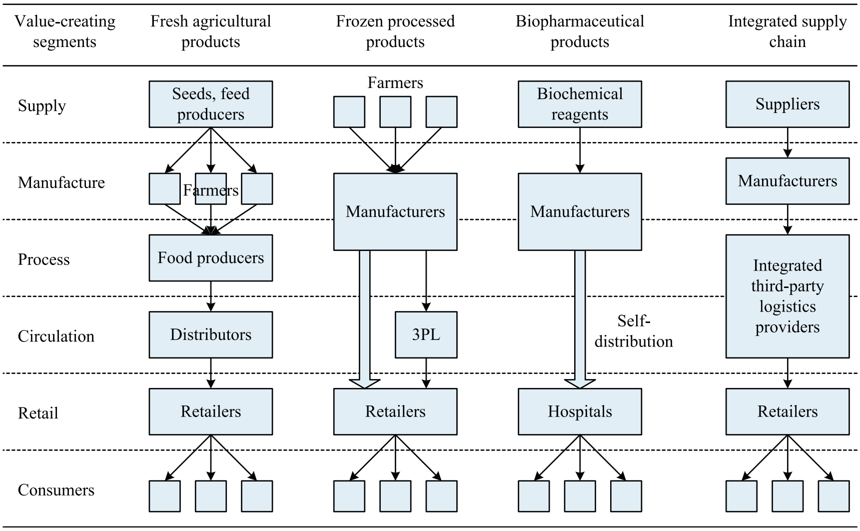

Figure 10.4 Supply chain structures of cold chains in China.

products are packaged for transportation or processed for easier storage by big food producers, and sales and product logistics are usually organized by numerous distributors. The big food producer or distributor in China is usually the leading/key firm in the supply chain. Thus, the agricultural food market is almost perfectly competitive in each segment. Most farmers and distributors in China are too small and have no capabilities to invest in dedicated cold-chain facilities and assets.

The frozen-product industry (third column of Fig. 10.4) in China is a monopolistic competition market with several well-known brands. The food manufacturer is the core enterprise in the supply chain and is oriented to customer demands. The frozen-food manufacturers adopt different sales channels, either through distributors or through subsidiaries for direct sales. Frozen products have certain special infrastructural requirements for distributors, such as refrigeration warehouses and cold-chain transportation equipment. If these and other cold-chain resources are relatively scarce in the industry, the distributor will have high bargaining power owing to a lack of substitutability. For that reason, the distributor pattern is vulnerable under a market environment characterized by uncertainty.

The biopharmaceuticals supply chain (fourth column in Fig. 10.4) includes R&D institutions, manufacturers, pharmaceutical distributors, and hospitals as the retailers. The distribution segment of the cold chain involves multiple parties and thus the subcontracting problem increases risk. Furthermore, the multibatch, small-lot shipment pattern does not enable an economic scale of transportation to be achieved.

10.5 CASES IN CHINA

In this section we review four cases in China and illustrate their supply chain structures (Fig. 10.4).

10.5.1 China Oil and Foodstuffs Corporation: Integrated Cold-Chain Services

China Oil and Foodstuffs Corporation (COFCO) is China's largest group in food processing, manufacturing, and trade. Founded in 1952, COFCO is a state-owned enterprise specializing in the import and export of cereals, oils, and foodstuffs. Accompanied by improvements in the market mechanism in China, COFCO began its product-based diversification process in 1992, transforming from a traditional trade agent to a grain and oil food-processing company. Today, COFCO is a diversified group involved in a range of activities including the foodstuffs business, finance, transportation, warehouses, and port facilities.

With the elimination in 2008 of the control on dealing commodities after entry to the WTO, COFCO had a second shift in strategic positioning in the context of international competition. COFCO oriented its position to become the main channel within China's grain market and trade, the leader of food supply integration, and an internationally competitive grain merchant. It proposed an integrated supply chain strategy early in 2009, with the aim of building a comprehensive plant—process—logistics—trade industry pattern.

COFCO's integrated supply chain strategy can be divided into two aspects. One is the vertical integration of the single-product supply chain, specifically, integration of the processing of raw materials and supply services upward, and entry into the sales areas. Through the vertical integration of products, services, and information between the upstream and downstream processes, COFCO tightly controls the food supply and distribution process and internalizes the supply process. The other aspect is the horizontal integration of different industry chains, whereby COFCO integrates the logistics, finance activities, and sales channels of various industry chains.

The integration strategy drives the structural changes in ownership investment, sales channels, and the supply system. In the main, COFCO completes the strategic layout through large-scale investment, mergers, and acquisitions. On the one hand, COFCO invests in grain and meat processing bases in different regions of China and collaborates with grain-planting bases and farms to improve the supplies of raw materials and to smooth the cold-chain logistics process. On the other hand, it takes over well-known food brands to enter the downstream sales field. Furthermore, COFCO attempts to make its own sales in online brand stores rather than through common agencies, such as grocery stores. COFCO has established a B2C e-business platform *Womai* to reach customers directly and to create brand recognition.

A supply system with integrated cold-chain services is the key success factor of food supply chains. COFCO conducts strategic planning for its logistics system and the layout of logistics nodes. COFCO's logistics system is composed of warehousing and processing centers in producing areas, distribution centers in sales areas, and transshipment centers in seaport and riverport terminals. As an example, COFCO's food logistics park in Shenzhen is the core part of its cold-chain supply network in Shenzhen and Hong Kong, providing professional cold-chain services for its own food supply chain and for other food companies. The park has 50,000-ton-capacity refrigeration warehouses, a 150,000 m^2 normal-temperature warehousing and distribution center, and a 50,000 m^2 food-processing and service center. These facilities allow COFCO to provide comprehensive integrated cold-chain services, including storage, processing, distribution, and regional transshipment services.

COFCO integrates raw material suppliers, distributors, and logistics providers to reduce both production costs and transaction-related costs. The value of brand is another incentive for forward integration.

10.5.2 Yili Group: Backward Integration

Yili Group is a leading brand of dairy products in China. It is engaged in the processing and manufacturing of milk products, including fresh milk, milk powder, and ice-cream. Compared with other dairy companies, Yili Group has the competitive advantage of being the largest high-quality source of milk in northern China. In its internal organization, Yili Group takes a divisional organizational form consisting of the liquid milk division, the milk powder division, the yogurt division, the raw milk division, and the ice-cream and beverage division. Each division has its subsidiary companies and is in charge of the delivery of products to retailers. In the early stages, Yili Group's distribution network was production site based and supported with different transportation modes.

As the geographical distribution of milk production and consumption is imbalanced, long-distance transportation is time consuming and costly. More importantly, it cannot meet the increasing requirement of freshness and quality in the final market. With market expansion, the original distribution network is no longer suitable for future development. For that reason, the major challenge for Yili Group was how to effectively shorten the distribution time to its end-customers. Customer orientation and quality is the core value of Yili Group. To ensure the quality of its products, Yili focuses on the control of upstream milk supply and adopts a backward integration strategy.

The integration of upstream pastures is seen as a means of achieving quality control and cost reduction. Yili Group places much effort in developing its own pastures through self-building, acquisition, and collaboration. Also, production factories are built in the major cities, which have the largest milk consumption. Through collaboration with both local dairy farmers and the government, Yili Group has built a network of regional milk-producing bases in more than 10 cities. This has greatly shortened the transportation distance and reduced the distribution time for delivering cold-chain products to the market.

Yili Group has implemented a flat structure to achieve quick responses. For example, for liquid milk, the milk-source—factory—distribution—centralized-retailer structure is the general pattern used. A distribution center has been built to meet the needs of small- and medium-sized customers in the appropriate time frame. In the milk production area, another supply pattern is directly from the factory to the consumer. The elimination of a distributor level simplifies the cold-chain process and thus reduces distribution time and ensures the quality of the product.

To ensure the quality control of each process, Yili Group utilizes an enterprise resource planning system to integrate the information from fresh milk stations to retailers. In the upstream, Yili Group establishes a data record for each cattle unit for the convenience of trace-back. In the downstream, the inventory information of retailers is transmitted in real time to Yili Group. Transportation information is obtained through tracking milk lorries using a Global Positioning System.

10.5.3 China Railway Express Co. Ltd. Supply: Integrated Transportation

Fast, service-demanding transportation has increased the opportunity for the integration of modes via joint ownership or special arrangements, i.e., joint distribution and integration through third-party logistics. China Railway Express Co. Ltd. (CRE) is the largest domestic rail express company and a subsidiary of China's Ministry of Railways. CRE has developed an extensive rail transportation network and auxiliary highway networks. Its core businesses include parcel delivery, express shipments, and contract logistics. CRE has operated a cold-chain supply service since 2007 based on its original package-delivery business. This service was widely welcomed by manufacturers of high-value perishable products, including the world's largest chocolate manufacturer (Mars China), several state-owned biopharmaceutical products research institutes, and other biopharmaceutical enterprises.

CRE investigated the cold-chain market and finally focused on two niche markets, one being the biopharmaceutical product market and the other being the high-end food market. Both of these markets are high profit and have strict requirements for temperature control and short delivery time.

Shipment of candy products requires controlled temperatures between 0°C and 20°C. Mars China also wanted to shorten their distribution time to the southern and northwestern China markets. For biopharmaceutical products, such as vaccines and insulin, the transportation temperature must be confined to 2–8°C. Both candy products and biopharmaceuticals need protection from moisture, dust, and odors as well as from theft and damage.

To meet these requirements, CRE chose railway baggage cars and package express trains as the main means of transportation, along with road feeder services. Based on advanced cool-storage refrigeration technology, CRE designed small containerized cargo units (SCCUs), which are a palletized, small cool-storage refrigeration container needing no internal power source. The container is equipped with cool-storage refrigeration slabs chilled to the necessary temperature and can maintain a constant temperature for 48–96 hours. The outside plastic material of these containers is lightweight but high strength, which minimizes shipping weight but provides sufficient durability to withstand the rigors of transportation.

The cold-chain supply costs can be divided into three parts: variable transportation costs, refrigeration costs, and management fees. From the perspective of cold-chain business activities, there are six main aspects,

Table 10.3 Cost structure of third-party cold-chain supply providers in China

	Unit	Unit cost (RMB/km)	Percent of total cost
Refrigeration	Per year	25	4
Package	Per round trip	21.31	15
Transport	Per container	1015	44
R&D	Per year	15.05	2
Information technology	Per year	15.4	2
Management	Per year	519.2	23

Based on a unpublished survey of a fresh food transport project (2009).

namely, freezing and refrigeration, packaging, transportation, R&D, information technology, and management. The refrigeration component refers to the energy consumption of freezing slabs and the operating costs of refrigeration equipment. Packaging includes equipment costs such as refrigeration slabs, depreciation costs, and packaging material costs. It is worth noting that transportation costs consist of two parts, namely, the cargo cost and backhaul cost. Table 10.3 provides information on the cost of each process. For the transportation cost, we assume that the transportation distance is 3000 km at a container turnover rate of 10 days.

Prior to using the SCCUs, Mars China had relied on trucks to deliver its chocolates from Beijing to Xinjiang Province, on the far western border of the country. Shipments that measured greater than 9 m^3 were shipped directly to the city of Urumqi—a journey of about 9 days. Those measuring less than 9 m^3 required two transfers, in Xi'an and Lanzhou, which lengthened the delivery time to about 14 days to Urumqi and to 14–18 days to surrounding areas.

With the introduction of CRE's SCCU model, transit times have been substantially shortened. It now takes just 4 days for Mars China's shipments to reach Urumqi and only 4–6 days for delivery to surrounding cities. Both the transit times and the time taken to receive signed "bills of lading" from the consignees have been reduced by more than 50%.

10.5.4 Cross-Border Fruit Transport

The Association of Southeast Asian Nations (ASEAN) is the key cooperation region under the Belt and Road Initiative (BRI) proposed by China.[1] China-ASEAN trade increased from US$192.6 billion in 2008

[1] The BRI refers to the Silk Road Economic Belt and the 21st century Maritime Silk Road.

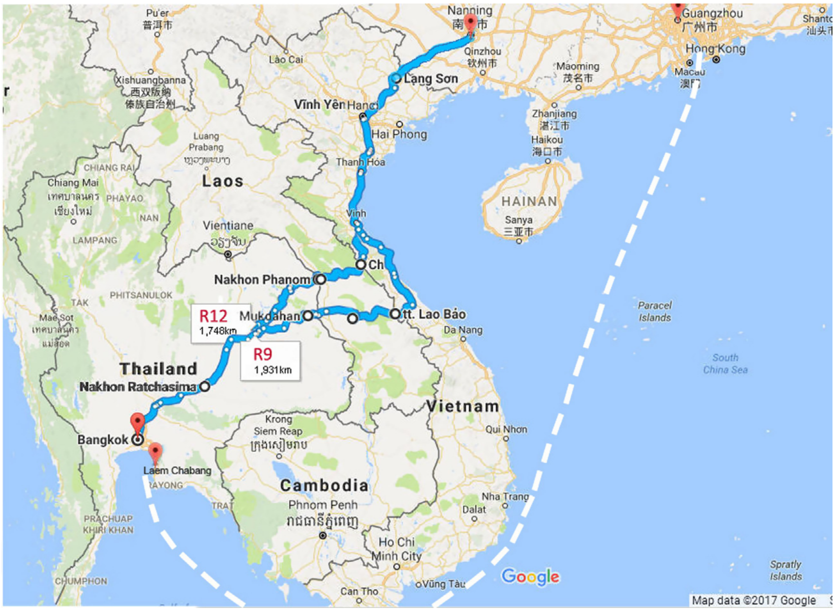

Figure 10.5 Thailand–China shipping route and overland route of fruit transport.

to US$452.2 billion in 2016. In this context of booming trade, China is increasingly sourcing from the region, especially from the Greater Mekong Subregion (GMS) countries. Besides two provinces of China (specifically Yunnan Province and Guangxi Zhuang Autonomous Region[2]), GMS includes five countries located in the center of Indo-China Peninsula, namely Cambodia, Laos, Vietnam, Myanmar, and Thailand. Cross-border trade has improved significantly in the last years. There is a huge demand in China for tropical fruits, flowers, and other agricultural products from Thailand and Vietnam.

Fruits and other agricultural products from Thailand are traditionally exported to China by sea transport. Fresh fruits stored in refrigerated container are shipped from Laem Chabang Port to Guangzhou Port and then transshipped to Guangzhou Jiangnan Market. Through this largest fruit market in China, fruits are finally distributed to cities of South China. The white dashed line in Fig. 10.5 shows the fruit cold chains of ocean

[2] Guangxi is located in the South China and has a unique location connecting China to Southeast Asia. With the secure and efficient cold chains that connect major seaports and road junctions, Guangxi is key to linking up the food sectors in the Mainland, the ASEAN countries, and other countries. Under the Beibu Bay Development, Guangxi will continue to play a pivotal point as a trading center in the China-ASEAN.

shipping route, i.e., Laem Chabang—Hong Kong—Guangzhou. It takes about 6—7 days from the export port to the import port. Due to the economies of scale of transport costs, currently sea transport is still adopted in large scale among transnational fruit trade. China bulk port system is advancing to handle higher import trade (Yang, Wang, Xu, & Zhang, 2017).

Fig. 10.5 illustrates the fruit cold chains from Thailand to China (by sea) and from Thailand to Laos to Vietnam to China (by road). Cold chains along the One-Belt-One-Road are multimodal.

Some fresh fruits, such as durian, mangosteen, and longan, are perishable, time sensitive, and relatively high priced. As these fruits require more rapid and more efficient delivery to the consumers in China, they are increasingly transported through land transport by refrigerated container trucks. Fruits from orchards in South and Southeast Thailand are converged by fruit wholesalers or exporters to Bangkok, and then loaded on refrigerated trucks by cross-border logistics service providers. There are two main corridors for fruit cold chains to Nanning in China by way of Laos and Vietnam, known as R9 and R12. They are identified by blue (gray in print version) line in Fig. 10.5. R9 starts from Bangkok, passes through Mukdahan—Savannakhet border crossing between Thailand and Laos, Dansavan—Laobao border crossing between Laos and Vietnam, Langsan—Youyiguan border crossing between Vietnam and China, and finally reaches Nanning in Guangxi Province of China. The total length of corridor R9 is 1931 km, and the average transport time is 33.5—37.5 hours. The total length of corridor R12 is 1748 km, for trips of 28.5—30.5 hours. The borders on R12 are NakonPhanom (Thailand)—Thakhek (Laos), Naphao (Laos)—Chalo (Vietnam), and Langsan (Vietnam)—Youyiguan (China). R12 is the fastest corridor between Bangkok and Nanning, which is now favored by most fruit logistics service providers. These two transnational land transport corridors have different highway grade, pavement quality, and speed limit in different segments. Most segments of the highways are single lane. In particular, segments of pavement near Naphao border in Laos are currently severely damaged. Thus, traffic congestions happen occasionally, which delays the delivery of perishable fruits.

The road infrastructure network within the ASEAN countries determines the accessibility of the international land transport corridors, while the cross-border transport mechanism within the ASEAN countries influences the efficiency of transport procedures. GMS countries signed and implemented GMS Cross-Border Transport Facilitation

Agreement (CBTA). The agreement focuses on transport and trade facilitation measures that enhance connectivity across international borders and improves linkages among the six GMS countries for increased cross-border trade and investment. It covers various measures such as elimination of intermediary stops or transshipment, one-stop single-window customs inspection, facilitation of movement of persons and goods, and standardization of requirements for infrastructure and vehicles. When fully in place, the CBTA is expected to greatly reduce the amount of time spent in crossing borders and promote cross-border and third country trade.

Nevertheless, border issues are still a main barrier for regional cross-border trade. The refrigerated container needs to be replaced on another truck before enter the third country. For example, Thailand and Vietnam freight vehicles are not allowed to enter each other through Laos, because vehicle standards diverge and the road sizes differ. Cargoes or containers need to be reloaded on local vehicles in a car park near the border. Also, documents for customs clearance need to be reprocessed when crossing the border. These operations bring increases of both transit time and vehicle switching and container handling cost. Furthermore, there is a significant lack of temperature-controlled equipment and facilities for cross-border cold-chain logistics. As a result, large amounts of perishable goods are wasted.

In the foreseeable future, there will be tremendous market growth of fresh tropical fruits from ASEAN countries in China. With the closer collaboration between China and ASEAN under the Belt and Road Initiative, improvements of cross-border fruit transport in the regional situation are expected. It is also expected to boost the infrastructure connectivity and facilitation of cross-border trade among member states of ASEAN.

10.5.5 Key Findings of Case Studies

It is crucial to match the supply chain strategy with specific products for the manufacturing company in the cold chains. In Fig. 10.6, we summarize a simplified framework of supply chain strategy selection. The two dimensions based for selection are value created in the manufacturing process and the interdependency with the upstream and downstream firms. The former dimension is derived from the perspective of profit margin in the value chain. It reflects the profitability of the producing

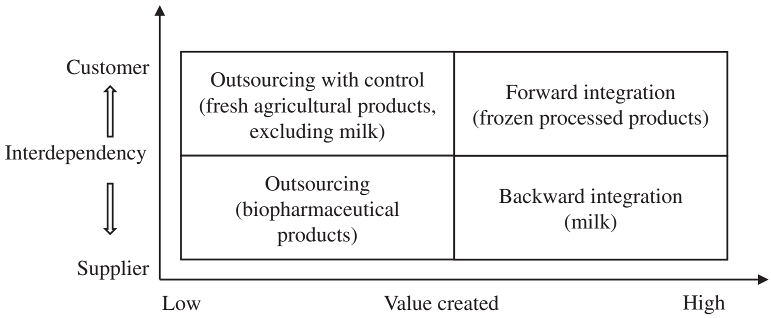

Figure 10.6 Matching supply chain integration strategy to cold-chain products.

segment. The latter dimension is the relationship of the manufacturing company with upstream and downstream partners in the supply chain. It reflects the product's competitive edge.

Low-value-creation manufacturers with low-value-creation-producing processes intend to outsource cold-chain supply activities beyond production to reduce costs. For example, the biopharmaceuticals manufacturer, which has a relatively low profit margin in the value chain, is prone to outsourcing the transportation and distribution of drugs. As it is closely related to the upstream firms, the company might choose to buy advanced product technology to improve the quality of the product and productivity, or, in the case of the big firms, to invest in R&D.

Manufacturers enjoying the high value created in the producing process have the incentive to adopt supply chain integration to maximize the monopoly profit. Backward integration is suitable for firms that desire dedicated assets and a reduction in supply uncertainty. The backward integration strategy is more appropriate for firms who want to create the value of brand.

This can be used to explain why manufacturers in different sectors within the food industry exhibit different preferences for cold-chain organization. The frozen-product and other processed-food producers choose a forward integration strategy to pursue greater profit margins and to quickly respond to customer demands. They cut out the distributor level and sell directly to the retailer or customer to achieve forward integration. The fresh-milk producer needs quality control from the raw sources, and manufacturers are prone to integrate upstream supply and run their own refrigerated logistics, even suffering large investments and high logistical costs to do so.

10.6 CONCLUSIONS

In this study, we have applied value-chain analysis and examined the supply chain structure. The "value-chain analysis" is product oriented and is suitable for a single product. The "supply chain structures" can provide information about different organizations and their behaviors in different market structures. Diagrams of supply chain structures can illustrate the interactions between organizations along the value chains.

We have analyzed integration in cold chains in China. In particular, for three different cold-chain products, different integration strategies will be adopted. We analyzed the integration cases of China's three leading cold-chain service providers. Based on the value-chain analysis, we proposed the policy and direction for the cold-chain industry in China.

There is huge potential for growth in the emerging cold-chain market in China, especially with regard to increasing the rate of cold-chain supply. With the growing requirements for high-quality food by end-consumers and for increases in quality assurance from food businesses, we believe that the rising and urgent demand will drive a rapid increase in the development and adoption of cold-chain supply. As railways possess an advantage in long-distance transportation, we further predict market space for long-distance cold-chain transportation.

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CHAPTER 11

Choosing Cross-Border Financial Guarantee Instruments—Economic Implications and Hidden Risks

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11.1 INTRODUCTION

Billions of cargo containers cross international borders annually, in order to deliver goods to end consumers or simply to be consigned to next production stages and transformed into semifinished or finished products (Hummels, 2007). An important stakeholder in cross-border movements is represented by customs administrations (Widdowson, 2007), which have three important roles: (1) to protect society from safety and security threats (e.g., health or terror risks), (2) to facilitate collection of taxes and duties associated with goods passing the borders, and (3) to identify and interdict illegitimate trade such as smuggling or transportation of prohibited items (e.g., weapons, drugs, counterfeit products) as stated in nationally enforced regulatory frameworks (Tan, Bjørn-Andersen, Klein, & Rukanova, 2010; Urciuoli, Hintsa, & Ahokas, 2013).

Taxes and duties are typically charged to end consumers once they purchase the goods (Arvis, 2005; Hummels, 2007). However, it often happens that before reaching the country of destination (where the goods will be sold), cargo will merely transit countries and the transport carriers will need to request a temporary suspension (Arvis, 2005), for instance, through a direct cash deposit (CD) or a financial guarantee (EC, 2017b). This procedure brings additional costs to transport companies, ultimately affecting cash flows and related marginal revenues. Hence, it may be wondered what financial instruments are available to transport companies and how transport companies should choose among them in order to minimize costs.

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To the knowledge of the authors, costs and potential risk implications of financial guarantees seem to be under-explored in existing literature. Some studies highlight that tariffs applied on cargo moved cross-border constitute a barrier to trade and ultimately affect distribution network strategies (Anderson & Van Wincoop, 2004; Chopra, 2003; Finger & Yeats, 1976; Hummels, 2007). However, in these studies, there is no indication that cargo may need to transit across several borders, pushing additional costs to transport carriers. The importance of this issue is testified by other available research emphasizing how costs typically affect transport companies' cash flows. Financing many of these costs is a significant issue for carriers, who continuously struggle to keep costs low in order to cope with the aggressive auctions driven by transport buyers (Urciuoli, 2016). Typical cost items are classified as direct fixed and variable expenses, as well as externalities or indirect costs that are collected by governments through mechanisms like congestion prices, environmental taxes/fees, etc. (Levinson & Zhao, 2012). These costs are important to quantify in order to be correctly internalized in freight service prices (Forkenbrock, 2001). Nevertheless, there is no known study exploring the costs of financial instruments to temporarily suspend tariffs.

Hence, this chapter, by means of an illustrative case study in the BSEC region, will elaborate on the impacts of different instruments at the disposal of transport companies to finance temporary suspension of taxes and duties. Focus will be on impacts on costs as well as operational risks.

This chapter is organized as follows: the context and the main focus of the study are introduced in the first section, followed by the second section summarizing the relevant literature in the following research areas: institutionalism, financial and operational risks for transport companies. Next, a case study based in the BSEC region is expounded with specific focus on customs institutional pressure generating financial charges and additional risks to transport companies. Finally, the case is discussed in view of previous research and main conclusions highlighted.

11.2 INSTITUTIONAL PRESSURE

To guarantee compliance with regulatory frameworks by companies, customs require better visibility on carriers' processes and documentation. Depending on the level and quality of information that carriers submit to customs administrations, a physical check of the goods could be triggered (Appeals & Struye de Swielande, 1998). Hence, activities driven by customs administration have been proven to generate nuisances to companies' operations, hence risks may appear in terms of loss of performance or even economic losses due to penalties or fees (Tan et al., 2010). For this reason, governments worldwide have put in place trade facilitation programs aiming to reduce the negative impacts of customs activities, e.g., through the application of simplified procedures, e-customs platforms, or by simply increasing transparency and professionalism of customs officers (Urciuoli et al., 2013).

The interaction between customs administration and transport operators is important to be explored and understood. In particular, institutionalism is a relevant framework to consider since it defines how external social, political, and economic pressures influence firms' strategies and thereby organizational decision-making (Glover, Champion, Daniels, & Dainty, 2014). The overall idea is that institutional theory does not consider firms as rational actors but rather as entities seeking for legitimacy of their practices by simply following enforced regulations, or adapting to contexts by imitating their peers (Chung & Wee, 2008; Dimaggio & Powell, 1983). In the context of customs institutional pressure toward transport carriers, it can be deduced that customs administrations apply a coercive pressure on companies; specifically, through regulatory frameworks which companies willing to import/export goods have to comply with (Dimaggio & Powell, 1983; Simpson, 2012).

Previous research has investigated the influence of institutional theory frameworks in transportation, operations management, and supply chain management. Panayides, Parola, and Lam (2015) study the effect of institutional factors on the application of public—private partnerships (PPP) in ports. In particular, PPP success is influenced by factors such as "regulatory quality," "market openness," "ease to start a business," and "enforcing contracts." Other authors agree that institutional pressure may affect the performance of supply chains, impacting lead times, response time, picking activities costs and network location choices, risk management practices, etc. (Chopra, 2003; Gebennini, Grassi, Rimini, & Depietri, 2013; Gopal & Gao, 2009; Ketokivi & Schroeder, 2003; Tate, Ellram, Bals, & Hartmann, 2009).

11.3 TRANSPORT RISKS

Several threats could strike a supply chain. Overall risks have been categorized according to the location gaps between the source of the risk and the focal company of the supply chain. Typical risks addressed are those related to the flows of materials, information and money, and finally demand and supply risks (Manuj & Mentzer, 2008; Viswanadham & Gaonkar, 2008). Another important group of threats considered as supply chain risks are operational disturbances, tactical disruptions, and strategic uncertainties (Lockamy III & McCormack, 2009; Peck, 2006). Overall, the underlying belief is that a risk, originating in some part of the supply chain and involving its flows, triggers a deviation from normal operations leading to a state condition where losses or additional costs are experienced by the supply chain actors (Knemeyer, Zinn, & Eroglu, 2009; Pfohl, Köhler, & Thomas, 2010; Viswanadham & Gaonkar, 2008). Typical operational risks that can take place during transport include delivery delays, traffic jams, and employee work stoppages. Although it is often not possible to precisely predict the occurrence of such events, it is possible to evaluate the probability of their occurrence along with the consequence through the creation of companies' risk profiles (Lockamy III & McCormack, 2009).

Some authors point out that often supply chain risks are triggered by the actions of the external environment, e.g., public authorities, which on one side are meant to safeguard society, but on the other may imply severe economic consequences to supply chains. For instance, Sheffi (2001) suggests that measures taken by governments to improve homeland security might end up burdening supply chains, creating queues at borders and thereby longer and less reliable lead times. Other authors label these threats as regulatory compliance risks (Muradian & Pelupessy, 2005; Urciuoli et al., 2013). Customs controls at borders lead to tedious checks, delays, bureaucracy, and inconvenient form-filling. These checks interfere with the free flow of goods at borders, resulting in delay risks, i.e., additional time to ship and thereby increased costs.

Losses or additional costs related to transport risks can assume different magnitudes depending on several factors such as the type and time length of disruptions, and the recovery measures or strategies put in place by the company. The final outcome that is relevant for the supply chain includes additional costs due to interruptions in business operations, or other undesirable consequences such as delayed deliveries or lost sales (Svensson, 2002).

11.4 FINANCIAL GUARANTEE MODELS

Customs control is perceived as an interference or a disturbance by operators. Cross-border regulatory frameworks are normally enforced through specific processes, routines, and form-filling to be followed by companies, i.e., additional costs for companies (Appeals & Struye de Swielande, 1998). The bureaucratic workload for carriers or freight forwarders increases exponentially, especially considering that often these companies move mixed cargo, hence different laws and regulatory framework will need to be considered.

One important requirement for border crossing concerns the collection of taxes and duties (Arvis, 2005; Hummels, 2007). While these are normally charged to the buyer of the goods located in the destination country, transport carriers still need to ensure that the relative amounts are secured in the customs bank accounts. Customs duties and other charges applicable to goods are temporarily suspended when goods are released for common/Union transit (EC, 2017b). This implies that a (customs) debt is incurred in the course of a transit operation, and the holder of the procedure is required to furnish a guarantee (Arvis, 2005; EC, 2017b). The supply chain operator (normally the transport carrier) responsible to issue the guarantee has at disposal three options: furnish the guarantee as: (1) a CD, or (2) using a guarantor covering a single transit operation ("guarantor single transactions (GST)" option), or (3) using a comprehensive guarantee covering several operations ("guarantor aggregated transactions (GAT)" option) (EC, 2017b). Finally, an operator has the option to purchase "Transports Internationaux Routiers (TIR)" carnets and use the attached vouchers to automatically cover the necessary guarantees at the country borders (EC, 2017a).

11.5 SUMMARY OF LITERATURE

Fig. 11.1 is a summarized framework deduced from the literature reviewed. In the top part of the figure, customs' three main pillars of regulatory frameworks are expounded as the main sources of institutional pressure on companies (i.e., safety and security, revenue collection, and interdicting illicit trade). This pressure can be of two types, coercive and mimetic, depending on whether the regulations are mandatory or voluntary (Dimaggio & Powell, 1983; Urciuoli, Mohanty, Hintsa, & Boekesteijn, 2014). This pressure seems to create additional risks for transport carriers. First of all, the cash flow of the companies involved in cross-border operations is affected due to the necessary deposits to suspend taxes and duties levied at cross-border (Arvis, 2005; Hummels, 2007). Next, the same pressure implies risks like operational delays,

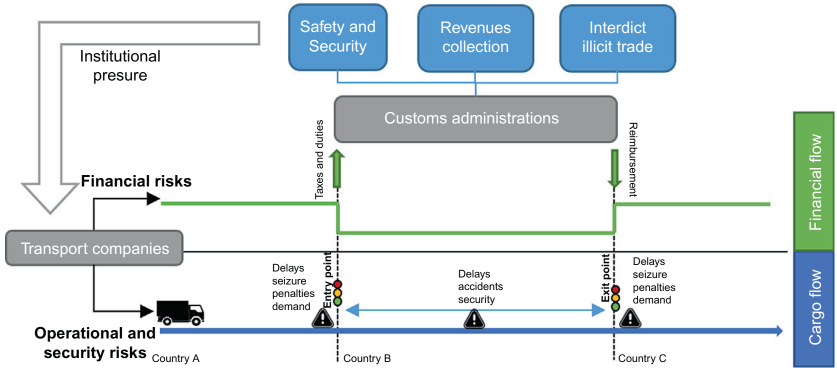

Figure 11.1 Summary of theoretical framework.

Figure 11.2 Overview BSEC area.

increased bureaucracy, potential fines and fees, and even security in case of theft during transport in the transiting countries. Finally, there is a high level of interrelationship between financial and transport risks. The cash flows from companies that are deposited into customs accounts are time dependent. Hence, any time delays or security issues taking place en route may have incidental effects on financial risks, increasing the complexity of managing these risks as well as the ultimate potential economic losses for companies. By using this framework this study aims to describe type and magnitude of these risks (Fig. 11.2).

11.6 CASE STUDY—THE BLACK SEA ECONOMIC COOPERATION REGION

The Black Sea Economic Cooperation (BSEC) emerged in 1992 and was officially established in 1999 as a multilateral political and economic initiative aimed at fostering interaction among 12 Member States: Republic of Albania, Republic of Armenia, Republic of Azerbaijan, Republic of Bulgaria, Georgia, Hellenic Republic, Republic of Moldova, Romania, Russian Federation, Republic of Serbia, Republic of Turkey, and Ukraine (BSEC, 2017).

Members of the BSEC today cover an area of approximately 20 million square kilometers with a population of 340 million people, representing a large economic potential—reaching an intra-BSEC trade volume of USD 300 billion annually (BSEC, 2017)—with strategic transport and trade routes. According to the data from 2012 (Noyan & Güney, 2012), the region represents 7.6% of the overall world economy and its total GDP amounts to around 3.4 trillion USD. It is becoming Europe's major transport and energy transfer corridor.

The deployment of an efficient transport network among the Member States as well as promoting sustainable transport systems meeting economic, social, and environmental needs of the people in the BSEC region is the main focus of the Economic Agenda of the BSEC region. In fact, most important achievements have been done in the road and maritime infrastructure and the facilitation of road transport of goods.

The priorities for regional and intermodal development in the BSEC region have been integrated into the projects and initiatives since 1993 within the framework of the Asia—Caucasus—Europe transit corridor "TRACECA" supplemented by the Black Sea Pan-European Transport Area (PETrA), to guarantee the development of transport, efficient traffic management, safety, and environmental protection of all the countries in the region.

The development of intermodal transport in the BSEC region is crucial due to the capacity of connection between the Euro-Asia network and the Trans-European Transport Network (TEN-T) corridors. In particular, the Orient–East-Med corridor and the Rhine–Danube corridor are connected to the BSEC region, and provide a high potential for the trade and economic relations to the BSEC region and consequently to Europe and Asia (Grosch, 2016; Peijs, 2017). The Orient–East-Med corridor will connect central Europe with the maritime interfaces of the

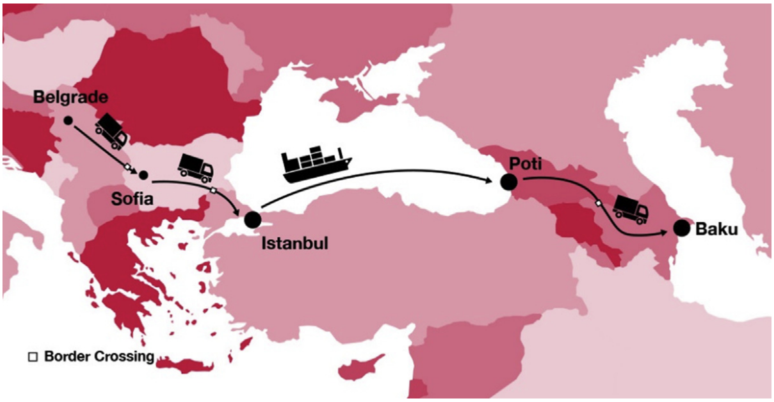

Figure 11.3 Intermodal transport flow considered in the BSEC case.

North, Baltic, Black, and Mediterranean seas, allowing the optimization of the use of the ports concerned and the related Motorways of the Sea. This corridor will foster the development of those ports as major multimodal logistic platforms and will improve the multimodal connections of major economic centers in Central Europe to the coastlines, using rivers such as the Elbe (Grosch, 2016). The Rhine–Danube corridor will provide the main east–west link between continental European countries, connecting France and Germany, Austria, the Czech Republic, Slovakia, Hungary, Romania, and Bulgaria all along the Main and Danube rivers to the Black Sea by improving (high-speed) rail and inland waterway interconnections (Peijs, 2017).

The case study discussed in this chapter analyzes shipments departing from Serbia to Azerbaijan, crossing the following countries: Bulgaria, Turkey, and Georgia. The shipment includes two intermodal shifts, road to sea in Istanbul, Turkey, and sea to road in Poti, Georgia (Fig. 11.3).

11.6.1 Financial Risks

According to gathered data, financial guarantees that can be used to move cargo across borders from Serbia to Azerbaijan are the following:

1. CD
2. GST
3. GAT
4. TIR carnet.

The four approaches have different financial implications. Four simple models have been developed to measure such impact. The underlying rule in the models is the same, i.e., analyzing and assessing the opportunity costs for depositing, for a limited time period (time elapsing from when entering the country until leaving it), the suspended taxes and duties.

11.6.1.1 Cash Deposit

In case of CD, the transport or logistics company in charge of the shipment is required to deposit its own financial resources into the bank accounts of the national customs transited. The model to compute the costs for using the CD approach is given in the following formula:

$$CDC_{Serbia-Azerbaijan} = \frac{S}{N \cdot 365} \cdot DIR \cdot \sum_{p=1}^{9} \sum_{c=1}^{3} \left[\left(VAT_{c,p} + DR_{c,p} \right) \cdot TV_p \cdot TT_c \right]$$

The model above includes the annual values of taxes and duties to be paid (right term summed over products and countries) on the route, multiplied by the deposit interest rate (DIR) and a conversion factor to calculate costs on a company-shipment basis. Terms used in the equation are:

$CDC_{Serbia-Azerbaijan}$ = annual cash deposit costs on route Serbia to Azerbaijan (€/company).

TT_c = transit time for country c considered in the route (days). Azerbaijan not included due to freedom of transit regime. Georgian duties and taxes considered only for bulk cargo (see Table A.2 for the estimated travelling times).

TV_p = annual traded values in € of each product p considered in the study (€) (see Table A.1).

$VAT_{c,p}$ = value-added tax in each country c, for each product p (%).

$DR_{c,p}$ = duty rates in each country c, for each product p (%).

DIR = deposit interest rate in Serbia (%), deduced from Serbian customs brokers rates issued for financial guarantees.

N = number of transport companies based in Serbia and assumed to be operating on the route Serbia to Azerbaijan (number of transport companies).

S = annual export shipments from Serbia (number of shipments per year).

c = countries selected for this study (1 = Bulgaria, 2 = Turkey, 3 = Georgia).

$p = 1$ to 9, corresponding to products selected for this study (see also Table A.1 in Appendix).

To calculate the annual cost savings, the following data were used:

- Annual trade values per product (Table A.1).
- Deposit interest rate 7% (WorldBank, 2016).
- Number of major companies operating in Serbia set to 107, as observed in available European yellow pages.
- Number of annual export shipments, from Belgrade and Dimitrovgrad (Upravacarina, 2016).
- VAT and duty rates as reported in World Trade Organization (WTO) tariffs database (WTO, 2016).

11.6.1.2 Guarantor Single Transactions

Using a guarantor means that a company has the option to request loans from national banks, insurance companies, or customs brokers in order to cover the necessary fees to be deposited in the customs' bank accounts. In case the guarantor is used for individual transactions, a company uses a guarantor for each time the company performs an export from Serbia to Azerbaijan. Hence the model that has been developed and applied is the following:

$$GSTC_{Serbia-Azerbaijan} = \frac{2}{73} \cdot \frac{S \cdot LIR}{N} \cdot \sum_{p=1}^{9} \sum_{c=1}^{3} \left[\left(VAT_{c,p} + DR_{c,p} \right) \cdot TV_p \right]$$

The model above includes the annual values of taxes and duties expected to be paid (right term summed over products and countries) on the route multiplied by the lending interest rate (LIR) and a conversion factor to calculate cost per company-shipment, but considering the limitation of 10 days maximum lending time. Terms used in the equation are:

$GSTC_{Serbia-Azerbaijan}$ = annual guarantor single transaction costs on route Serbia to Georgia (€/company).

TV_p = annual traded values in € of each product p considered in the study (€) (see Table A.1).

$VAT_{c,p}$ = value-added tax in each country c, for each product p (%).

$DR_{c,p}$ = duty rates in each country c, for each product p (%).

LIR = lending interest rate in Serbia (%). This value was calculated by using fees of Serbian customs brokers as a reference. According to interviews, customs brokers charge about €35–40 for a value of maximum €20,000 and a time limit of maximum 8–10 days. This corresponds to a potential lending interest rate of about 9%.

N = number of transport companies based in Serbia and assumed to be operating on the route Serbia to Azerbaijan (number of transport companies).

S = annual export shipments from Serbia (number of shipments per year).

c = countries selected for this study (1 = Bulgaria, 2 = Turkey, 3 = Georgia).

p = 1–9, corresponding to the 9 products selected for this study in Table A.1.

To calculate the annual cost savings, the following data were used:

- Annual trade values per products (Table A.1) as reported by WTO in 2015.
- Lending interest rate 9%.
- Number of major companies operating in Serbia set to 107, as observed in available European yellow pages.
- Number of annual export shipments, from Belgrade and Dimitrovgrad, (Upravacarina, 2016).
- VAT and duty rates as reported in WTO tariffs database (WTO, 2016).

11.6.1.3 Guarantor Aggregated Transactions

In case an operator chooses this option, a total amount loaned from the guarantor (a bank, an insurance company, a customs broker, etc.) has to be agreed upon and related costs paid. The guarantor monitors all transactions performed by the company's carriers. Thereafter the guarantor uses and refills the agreed budget respectively every time an amount needs to be deposited to customs' bank accounts, or the other way round, when the customs administrations reimburse the deposit. Using a guarantor for aggregated transactions performed yearly, the model is changed in order to consider to total amount of VATs and duty rates that need to be disbursed by companies to national customs on a yearly basis. Hence, the model is the following:

$$GATC_{Serbia-Azerbaijan} = \frac{1}{365 \cdot N} \cdot LIR \cdot \sum_{p=1}^{9} \sum_{c=1}^{3} \left[\left(VAT_{c,p} + DR_{c,p} \right) \cdot TV_p \cdot TT_c \right]$$

The model above includes the annual values of taxes and duties to be paid per shipment (right term summed over products and countries) on the route multiplied by the lending interest rate (LIR) and a conversion factor to calculate costs on company-shipment basis. Terms used in the equation are:

$GATC_{Serbia-Azerbaijan}$ = annual guarantor aggregated transaction costs on route Serbia to Azerbaijan (€/company).

LIR = lending interest rate in Serbia (%). This value was calculated by using fees of Serbian customs brokers as a reference. According to interviews, customs brokers charge about €35–40 for a value of maximum €20,000 and a time limit of maximum 8–10 days. This corresponds to a potential lending interest rate of about 9%.

TV_p = annual traded values in € of each product p considered in the study (€) (see Table A.1).

TT_c = transit time for country c considered in the route (days). Azerbaijan not included due to freedom of transit regime. Georgian duties and taxes considered only for bulk cargo (see Table A.2 for estimated travelling times).

$VAT_{c,p}$ = value-added tax in each country c, for each product p (%).

$DR_{c,p}$ = duty rates in each country c, for each product p (%).

N = number of transport companies based in Serbia and assumed to be operating on the route Serbia to Azerbaijan (number of transport companies).

c = countries selected for this study (1 = Bulgaria, 2 = Turkey, 3 = Georgia). Azerbaijan not included because of freedom of transit conditions.

p = 1–9, corresponding to the 9 products selected for this study in Table A.1.

To calculate the annual cost savings, the following data were used:

- Annual trade values per products (WTO, 2016).
- Lending interest rate 9%.
- Number of major companies operating in Serbia set to 107, as observed in available European yellow pages.
- VAT and duty rates extracted from WTO tariffs database (WTO, 2016).

11.6.1.4 Transports Internationaux Routiers Carnet

As established in the TIR Convention, companies have the possibility to cover customs duties and taxes throughout a journey, by exploiting the international guaranteeing chain managed by the International Road

Transport Union (IRU). Hence, the TIR carnet can be used by companies both as a customs declaration and as a guarantee for the duties and taxes suspended when cargo is transiting a country. National offices throughout the world have the responsibility to sell and distribute TIR carnet. For instance, in Serbia, the ministry of transport in cooperation with the chambers of commerce has this responsibility.

The economic model for the cost calculation associated with the TIR carnet is quite trivial. The costs for the suspended levied duties and taxes do not depend anymore on the value of the cargo nor on the transit time, or any loans borrowed from banks or insurance companies. Operators need merely to purchase a TIR carnet and automatically financial guarantee will be covered.

$$TCC = \left\| \frac{S}{N} \right\| \cdot TCP$$

where:

TCC = TIR carnet annual costs (€).

TCP = TIR carnet price (€).

S = annual export shipments from Serbia (number of shipments per year).

N = number of transport companies based in Serbia and assumed to be operating on the route Serbia to Azerbaijan (number of transport companies).

To calculate the annual costs of using TIR carnets, the following data were used:

- TIR carnet with 14 vouchers price €106.81 (UNECE, 2016).
- Number of major companies operating in Serbia set to 107, as observed in available European yellow pages.
- Number of annual export shipments (Upravacarina, 2016).

11.6.1.5 Numerical Analysis

A numerical analysis was performed by using the following underlying assumptions and/or data sources:

- *Georgian financial guarantees*: During interviews and observations performed in Georgia, customs post Sarpi, it was unveiled that financial guarantees in Georgia are not required, for all cargo except bulk. The information was verified by means of follow-up interviews with Georgian Revenue Services and analysis of legislative material. As it was explained, the freedom of transit is ensured by Article 230 of the Tax

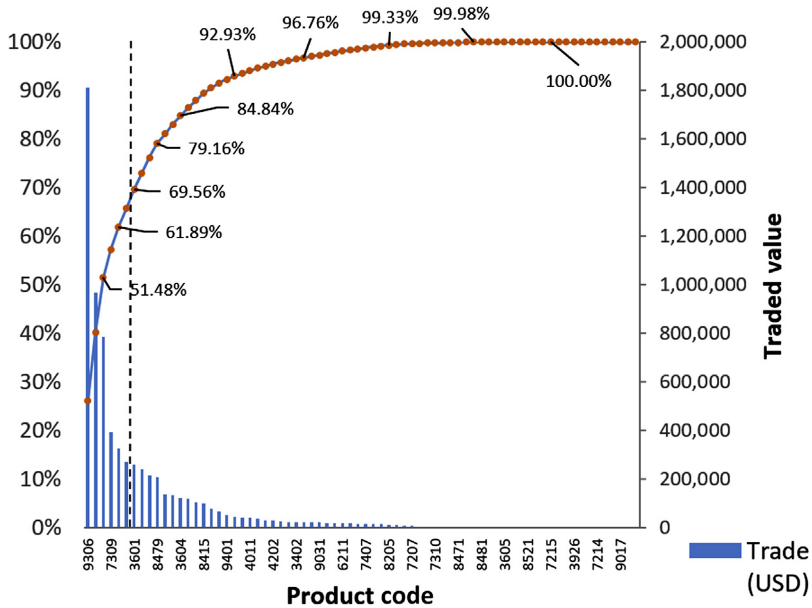

Figure 11.4 Trade Serbia to Azerbaijan in value (2015, in 1000 USD).

Code of Georgia and secondary legislation.[1] Hence, "transit in Georgia is free of any customs duties and does not require a guarantee in a form of surety, deposit, or other monetary or nonmonetary means." Additional interviews with customs brokers in Serbia confirmed that transit in Georgia is free of any duties and taxes, except for bulk cargo.

- *Azerbaijan financial guarantees*: Interviewed experts confirmed that all cargo products are free of duties and taxes in Azerbaijan as well.
- *Cargo value and product category*: Data collected from the WTO show that there are totally 72 types of products that are exported from Serbia to Azerbaijan, for a total 6,930,935 (thousands of USD). In order to limit the analysis but still keeping it significant in terms of results, it was decided to apply the Pareto principle and select merely products accounting for the 80% of the traded value between the countries of interest (Fig. 11.4). The selected products and related

[1] Instruction on Movement and Clearance of Goods across the Customs Territory of Georgia, approved by Order No. 290 of July 26, 2012, of the Minister of Finance of Georgia and Instruction for Implementation of Procedures Related to Entering Goods the Customs Territory of Georgia/Leaving the Customs Territory of Georgia and Declaration, approved by Order No. 12858 of August 1, 2012, of the Director General of the Georgia Revenue Service.

traded values are given in Table A.1, according to interviewed experts, TIR carnets are normally not used for transport of military cargo, hence product category (9306) has not been considered in the analysis (Table A.1).

- *Duty rates*: Duty rates used for the analysis have been computed by using the tariffs analysis database available from the WTO. The data available consists of the WTO's Integrated Database and Consolidated Tariffs Schedules. The computed duty rates have been identified by extracting applied duties rates averaged on the Harmonize System sub-headings (two digits) of the products considered in this study (see Table A.1), and for each of the countries transited, i.e., Bulgaria, Turkey, Georgia, and Azerbaijan.
- *Transiting times*: Transiting times have been estimated by considering:
  - The necessary traveling times to cross the selected countries. This item was computed by using google maps routing services. These times were slightly inflated considering (1) the necessary rest to be taken by truck drivers every 4–5 hours and (2) the slower trucks' average speed compared to normal cars.
  - The administrative time to file the necessary documents for issuing financial guarantees and request reimbursement where applicable.

In Fig. 11.5, results from the models are drawn in a diagram comparing financial guarantee costs per cargo taxes and duties values. It can be

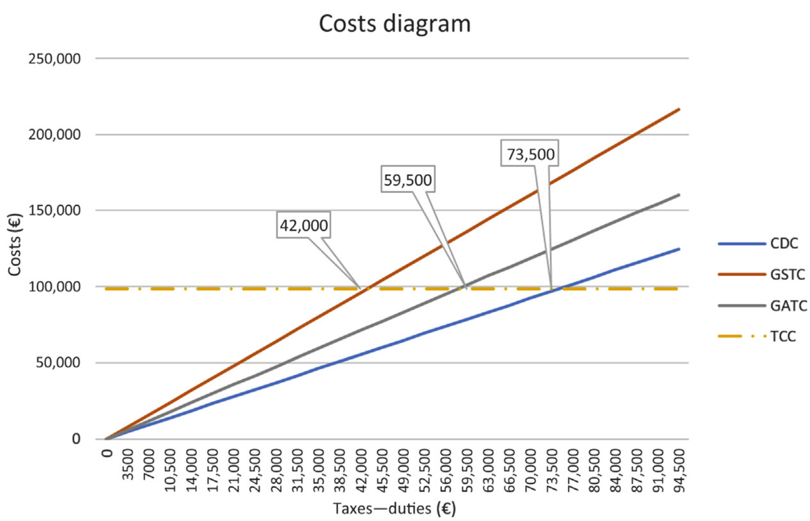

Figure 11.5 Costs comparison of CDC, GSTC, GATC, and TCC.

observed that three of the models' cost functions (i.e., CD costs (CDC), GST costs (GSTC), and GAT costs (GATC)) increase linearly with the total amount of taxes and duties to be guaranteed. The slopes of the lines tell clearly that among the three options, the cheapest for companies is the CD, followed by the GAT and finally the GST. Costs brought by TIR carnets are instead constant and independent from the value of the cargo up to a maximum of €100,000,[2] and considering a carnet with 14 vouchers. The total cost of this option is about €98,474. In the same figure, it is possible to notice three cutoff points in correspondence of €42,000, €59,500, and €73,500 (average container values). This implies that considering merely the benefits of financial guarantees, the TIR carnet is definitely an economically valuable alternative starting from containers with an average value of €42,000€ and above. The benefits are given by the respective regions in the diagrams between the cost functions GSTC-TCC, GATC-TCC, and CDC-TCC. For instance, comparing the GST option, benefits would range between €2000 and €140,000 per company. The cutoff points with the alternatives GATC and CDC have higher values, respectively €59,500 and €73,500.

11.6.2 Transport Risks

The most common definition of risk, which is the product of the "impact/consequence of the unexpected event" and "the likelihood of such event happening," is implicitly employed for transport risks. In this section we identify and discuss main risks in cross-border transport and their interrelationship with the financial instruments utilized by carriers. Table A.1 summarizes the risks of the four financial guarantee options based on the literature reviewed, as well as the data observed and gathered from interviews.

- *Freight demand*: Risk of shipping less or more than planned/budgeted. The number of containers a shipper needs to transport over a year cannot be predicted with certainty (i.e., random), and therefore shipping drastically more or less than the "expected" amount leads to financial losses or gains depending on the financial guarantees used.

[2] Starting July 1, 2016, the financial guarantee for TIR carnet has been increased from €60 000 to €100 000 for the following countries: Serbia, Azerbaijan, Armenia, Iran, Bosnia, and Herzegovina, as well as Kyrgyzstan.

- *CD model/GST/TIR carnet*: The deposits required are based on the "exact" number of shipments, and therefore there is no such risk for carriers.
- *GAT:* If the "exact" number of shipments is more (less) than the "planned/budgeted," the shipper ends up paying less (more) in total. Therefore, with this aggregate transactions model, the shipper (whoever deposits the guarantee) will benefit/suffer from the upside/downside risks. If the number of shipments is relatively stable over time, then such risks are minimal.

- *Border delays*: Entry and exit movement can be delayed due to screening of necessary transit documentation, including documents proving that necessary taxes and duties have been guaranteed by a CD, a guarantee, or TIR carnets.
  - *CD/GST/GAT*: Documentation supporting the deposits could vary depending on the bank or insurer used by companies. Lack of standardization increases uncertainty in time delays at borders.
- *TIR carnet*: TIR carnets could decrease these delays due to their high level of standardization, trust, and accreditation across customs administrations.
- *Transit delays*: Risk of the transport time being different than the planned durations. The transit time from the origin to destination also cannot be estimated with 100% accuracy, and therefore the financial guarantees that do not take into account the exact transit time are subject to this type of risk.
  - *CD model*: The deposits required are based on the transit time with the "CD" model, and therefore any delays will result in higher costs for the carrier.
  - *GST/GAT*: When the guarantor model is used, the guarantees are valid for transit times up to 10 days and therefore do not directly depend on the "exact" transit time. As a result, the shipper is subject to downside (upside) risks when the "exact" transit time turns out to be less (more) than the "average" transit time (average would most likely be half the maximum limit given a uniform distribution of transit times).
  - *TIR carnet:* The cost with the TIR carnet system is independent of the transit time, and thus no such risks exist with the TIR system as well.
- *Cargo value*: Risk of the value of shipments being less or more than planned/budgeted. Similar to the number of shipments, the "value" of the shipments over a year is unknown at the beginning of the year,

which causes the risk of paying less or more depending on the "actual value" shipped compared to the planned value. This risk appears only if the carrier uses the CD, the GST, or the GAT options.

- *CD model/GST*: If cargo value increases, the costs of CD and GST will also increase, increasing exposure to cargo value risks.
- *GAT*: With the GAT model, the value of the goods shipped over the year needs to be estimated at the beginning of the year, leading to the risk of the "exact" value of goods shipped deviating from this estimate, again with upside and downside risks.
- *TIR carnet*: The cost with the TIR carnet does not depend on the value of the container, and thus risk free.

- *Interest/loan rate fluctuations*: Due to fluctuations in the interest/loan rates over time, the party that pays for the financial guarantees in advance (i.e., when the goods shipped out of the origin) bears the resulting financial losses/gains. This risk is perceived significant only for the CD, GAT, and GST options.
  - *CD model/GST/GAT*: These options are all dependent on interest/loan rate fluctuations and therefore their pricing schemes could be easily affected in the short—medium term.
  - *TIR carnets*: Prices could also change in view of interest/loan rate fluctuations. However, due to the high number of agencies involved and the high volumes of carnets distributed, we believe that changes could be minimal.
- *Security risks*: In addition to the abovementioned risks, there are "security-related risks" that could be important in the decision-making process when choosing the most appropriate financial guarantee option. These risks are relevant for all the options considered. However, the TIR system offers better protection due to the auditing processed performed by national agencies to authorize the release of the carnets.
  - *CD model/GST/GAT*: Overall, these three options do not necessitate any sort of security requirements from the companies moving the cargo. Hence, these companies could be more vulnerable to attacks. For the same reason, customs risk management systems could classify these companies as high risks increasing border delays (as specified above).
  - *TIR carnets*: Companies that are using TIR carnets need to be approved by specific national agencies. This implies that companies have gone through financial and security checks. Therefore, risks for inspection at borders or during transit are minimized, since authorities trust TIR carriers.

11.7 DISCUSSION AND CONCLUSIONS

This study explores the costs and risks of different financial instruments for transport carriers. The analysis carried out considering transport flows in the BSEC area, from Serbia to Azerbaijan, shows that the choice of financial guarantees depends on the tax and duty value of cargo moved. CDs are the lowest-cost option costing up to €72,000, followed by the TIR carnets as the second cheapest option. Yet, some considerations must be put forward in the analysis shifting the cutoff point to lower values. First of all, companies, especially small-sized ones, hardly have the financial capabilities to afford the guarantees on their own. On the other hand, large enterprises, being often multinational companies, might have access to more attractive interest rates or investments that could significantly increase the opportunity costs of the CD option. Hence, while CDs seem to be an attractive option, it can still be considered a special case that could not materialize as a valid option for all companies. Likewise, the second option, the GAT, is feasible only if the company has been authorized by the local agency and if it can show stable and reliable forecasts of potential transactions along 1 year. Future research might be performed using surveys in order to segment transport carriers based on size, and estimate opportunity costs for depositing in cash the suspended taxes and duties.

In addition to the financial impacts, this study discusses the interrelationships between the financial guarantee options and cross-border/transit risks. Risks identified include freight demand, border and transit delays, cargo value, interests/loans fluctuations and security, and are summarized in Table 11.1. Overall, among the guarantees examined, TIR is certainly a low-risk option, while the remaining CD, GST, and GAT present higher uncertainties, implying that there could be hidden costs in these

Table 11.1 Overview risks impacts of the reviewed cross-border financial guarantees

	CD	GST	GAT	TIR
Freight demand	◌	◌	●	◌
Border delays	●	●	●	◌
Transit delays	●	○	○	◌
Cargo value	●	●	○	◌
Interests/loans fluctuations	●	●	●	◌
Security	●	●	●	◌

●, High; ○, medium; ◌, low.

options. In view of these risks, the TIR could be the preferred choice of companies despite a precise cutoff point cannot be computed. Hence, future studies should look into the quantification of these risks and integration in the cost analysis presented in this chapter.

Finally, the decision as to which financial guarantee model must be selected should not only depend on the costs and risks discussed in this research. There are other criteria which need to be carefully evaluated. We present some of these criteria that might cause the shipper to select a particular financial guarantee model or a combination of them (hybrid approach). At the same time, we suggest the following criteria as potential areas of future research:

- The models that provide coverage up to a certain limit on either the "value of the shipment" or "the time it takes to reach the destination" such as the GATC, GSTC, and TCC models lead to nonlinear cost structures (stepwise cost functions). For example, the GST offers guarantees up to a value of €20,000 and 10 days of transit time. If either the value or the total duration of the journey exceeds these limits, there could be additional costs. This would in general make these models more sensitive to small changes around the "limits" determined in the contracts. Moreover, the fixed cost to be paid to the customs broker under the GAT and the GST schemes might make the TIR and CD options financially more attractive. The CD model does not suffer from this as the cost is linear in the time and the value.
- Geographical coverage of the models (certain financial guarantees cannot be used in some regions across the world) and the customs duties in different parts of the world (e.g., there are no customs duties for Georgia (except for bulk cargo) and Azerbaijan) are important factors that need to be considered. The shipper and the carrier should evaluate how stable the number of shipments over a certain time period (e.g., year), the time in transit, the value of goods shipped for shipments that are destined to (or cross) different geographical regions. Depending on this analysis, a hybrid approach can be taken, where a combination of models is used for different regions. For example, if in Region X, the number of shipments is pretty stable and the volume justifies a "relationship-based model," then the GAT model can be used as you can predict with high accuracy the shipment frequency in advance. On the other hand, if the randomness in the number of shipments in Region Y is considerably high and there is not sufficient

volume, then the shipper would probably be better off using the GST model and pay for the insurance for each shipment separately (transactional).

- In order to simplify the operations, some firms might go for the financial model that is feasible for all regions and products rather than incurring larger administrative cost of managing a number of different financial models dealing with more intermediaries.
- The product heterogeneity is another factor that would be important as some products do not require duties. Also, the criticality of the products shipped (e.g., military equipment, hazardous materials, etc.) might impact the duties and therefore the choice of the financial model might be more important. Moreover, certain models cannot be used for some products (e.g., TIR cannot be used for the military equipment), which is another detail that needs particular attention in the design of the financial guarantee models portfolio.
- In the relationship-based model as in GAT (as opposed to transactional models such as GST), the carrier needs to "monitor" the shipments and make the payments accordingly using the budget agreed upon with the carrier in advance. There might be issues with the "monitoring," and therefore certain procedures must be put in place to ensure that the truthful information is being shared between different actors to avoid potential problems with reporting. This might result in some hidden costs that the shipper is not aware of at the time of signing the deal. In certain cases, a neutral third party might be necessary to resolve potential disputes.
- The shipper might consider the factors that lead to "no reimbursement" by the customs. Issues such as fraud, incorrect/incomplete information, security-related issues might increase the likelihood of not being reimbursed by the customs. Certain models could be more attractive if they reduce the probability of such events happening (e.g., the TIR system is supposed to improve information exchange and security). The cost of no reimbursement is not modeled in this research, however, we believe it is an important determinant of the model to be selected.
- The size of the shipper is another factor that might be important when it comes to the choice of the financial model. Whether the shipper/carrier is an small- to medium-sized enterprise or a big firm will impact the interest/loan rates, and therefore the choice of the appropriate model depends on the size of the firm.

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APPENDIX

Table A.1 Selected products and values traded from Serbia to Azerbaijan

Product code	Definition	Quantity	Short name	Value (in 1000 USD)	Cumulative %
9306*	Bombs, grenades, torpedoes, mines, missiles, and similar munitions of war and parts thereof; cartridges and other ammunition and projectiles and parts thereof, including shot and cartridge wads.	48683	kg	1,813,432	26.16
4911	Printed books, newspapers, pictures, and other products of the printing industry; manuscripts, typescripts, and plans.	7	kg	968,581	40.14
3004	Pharmaceutical products.	239602	kg	785,791	51.48
7309	Reservoirs, tanks, vats, and similar containers for any material (other than compressed or liquefied gas), of iron or steel, of a capacity exceeding 300 L, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment.	38918	kg	394,502	57.17
8414	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof.		N.Q.	327,503	61.89
8703	Vehicles other than railway or tramway rolling-stock, and parts and accessories thereof.	15	Item	270,603	65.80

(*Continued*)

Table A.1 (Continued)

Product code	Definition	Quantity	Short name	Value (in 1000 USD)	Cumulative %
3601	Propellant powders	16000	kg	260,651	69.56
8207	Interchangeable tools for hand tools, whether or not power-operated, or for machine tools (e.g., for pressing, stamping, punching, tapping, threading, drilling, boring, broaching, milling, turning, or screw driving), including dies for drawing.	10128	kg	242,167	73.05
9207	Musical instruments; parts and accessories of such articles.		N.Q.	216,333	76.17
8479	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof.		NQ	206,761	79.16

*TIR carnets are normally not used for transport of military cargo, hence product category (9306) has not been considered in the analysis.
Values are in 1000 USD from 2015, kg, kilograms; NQ, not quantifiable, product codes based on H4 nomenclature.
Data extracted from WITS (2016).

Table A.2 Estimated times in days for road and sea transport, as well as administration of financial guarantees

	Serbia	Bulgaria	Turkey	Georgia	Azerbaijan
Road transport	0.06	0.19	0.21	0.29	0.42
Sea transport	0	NA	3.54	NA	NA
Financial guarantee administration	0.08	0	1	2.04	0.04
Total	0.14	0.19	4.75	2.33	0.46

Traveling times were estimated by using google maps; NA, not applicable.

CHAPTER 12

Regional Effects of Port Free Economic Zones on Real Estate Speculation: A Korean Case Study

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12.1 INTRODUCTION

The dry bulk industry is prone to boom and bust cycles that become speculative phases during periods of excessive market exuberance. Moreover, research verifies that, rather than treating these speculative effects as isolated industrial phenomena, they should be contextualized within a multidimensional framework. We understand that the interrelation between commodity markets and freight rates leads to market spillovers, thereby allowing speculation to be transmitted from one market to another. As shown in UNCTAD (2015), the important role played by freight rates in the industry investment decision impacts on the regional dynamic and can, as a result, spread speculative periods to the regional economy. Given that the port connects the sea with the inland, it acts as a gateway through which speculative effects can shift from the dry bulk industry outward to the regional economy.

In particular, port locations and port investments are functional for international trade and also play a vital role in regional economic development, real estate prices, and land values (Fujita & Mori, 1996). The port development process often transforms an underdeveloped area into a modern port and can turn it into an attractive place for business, thus generating a dynamic property market and new land use opportunities (Notteboom & Rodriguez, 2005). From this perspective, public bodies and local authorities have always sought to provide innovative regional port policies that unlock regeneration and economic development in port cities (Merk & Dang, 2013). In this context, free economic zones (FEZs)

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are often implemented in order to foster regional economic activity and attract new business activities and investment in port cities (Xing, 2014; Song, 2015).

However, the long-term regional benefits generated by a port policy such as FEZ (Nijkamp, van der Bergh, & Soeteman, 1990) can also be undermined by speculative investments. In these circumstances, the development policy can overheat the real estate investment cycle, generate excessive expectation regarding future performance and, in so doing, drive land values upward by creating a speculative bubble (Malpezzi, 2000). Therefore it is paramount to gauge the extent to which the FEZ policy may develop in terms of excessive expectations and speculation in the real estate market.

This is particularly relevant in the case of South Korea, an Asian Far East economy that has been among the fastest growing OECD economies. Over the past 10 years, South Korea has returned an average annual growth of 10%, mostly fueled by a constant increase in international trade, especially for exports (OECD, 2014). However, structural issues, such as a lagging service sector, weak SMEs, lack of foreign investors, and research and development challenges have constrained South Korean growth (Bartzokas, 2007). In response to these challenges, for the past 20 years, the Korean authorities have been engaged in an ambitious program to develop FEZs in the largest port cities of the country. The program is designed to attract foreign investments, stimulate innovation, and boost international trade and finance.

In recent decades South Korea's major social and economic problems have been associated with its prolonged and sustained growth in real estate prices. As La Grange and Jung (2004) assert, the process of market liberalization and credit expansion in South Korea have provided fertile ground to speculators, giving rise to a boom and bust cycle in the real estate market. In the aftermath of the speculative cycle of the 1990s, the Korean government implemented policies to prevent future speculation, but as Kim and Soo (2005) emphasizes, these policies are ineffective when the market becomes irrational; a shortage of housing supply creates inelastic demands that, in combination with low interest rate policy, may trigger a boom and bust cycle in the real estate market (Kim & Soo, 2005). As a matter of fact, between 1999 and 2009, Korea witnessed a dramatic increase in real estate prices that generated distortions in home equities, created housing affordability gaps, and leveraged the financial sector (Ha, 2010).

Given this background, the main objective of this chapter is to examine whether port characteristics and the creation of FEZs in South Korea may have boosted irregular real estate patterns, determined speculation and largely undermined the potential long-term benefits unlocked by the FEZ. We analyze the FEZs, port performance, and real estate prices in the South Korean cities of Busan, Incheon, and Ulsan using the data collected from the Central Bank of Korea and Korean Real Estate companies. The three cities are then grouped in accordance with the type of port in each city: gateway, multipurpose, or specialized. The quantitative analysis is divided into three steps/hypotheses. First, we first aim to evaluate whether or not real estate market performance is in line with the main economic indicators of the cities' economies. Second, we assess if significant differences are present in the risk perceptions of FEZ real estate performance in relation to gateway, multipurpose, and specialized ports. Third, we verify whether the presence of a FEZ creates a leapfrogging effect in the real estate market. Leapfrogging effects are development patterns where some urban areas experience a jump in real estate prices which subsequently encourages noncontiguous city development and potentially causes gentrification, urban sprawl, and segregation.

Our findings indeed demonstrate the negative effects of speculation in port development and FEZ performance. Although South Korea has already created regulation to prevent speculative behaviors, this chapter brings to the fore two important political economic considerations for regional development. First, although the FEZ plays a pivotal role (dynamo effect) in local development by enhancing regional attractiveness, competitiveness, and agglomeration, it may also provide fertile ground for real estate speculation. Second, in order to realize the benefits of effective integration of FEZs, they should be tailored to the specific characteristics of port areas.

The present chapter is organized such that Section 12.2 provides the rational background to the study and presents quantitative evidence in regard to macroeconomic trends in South Korea, our three cities of interest and FEZs. Thereafter, Section 12.3 describes the empirical framework, data, and assumptions. Section 12.4 presents the detailed specification of the models, illustrates the results of the analysis and discusses the significance of the research findings. Section 12.5 concludes the chapter by providing final remarks and policy implications.

12.2 SPECULATION AND FREE ECONOMIC ZONES: CASE STUDY MOTIVATIONS

As emphasized in regional economic theory, today's economic geography is characterized by the concentration of economic activities in cities

(Krugman, 1993). Specialization, economies of scale and market interactions have increased the level of urbanization and made international trade a key element in delivering economic growth (Fujita & Krugman, 1995). In this context, cities or more generally, geographic concentrations, emerge from endogenous forces such as the maximization of growth returns and minimization of transport costs. This effect leads to the renaissance of port cities and of the role played by ports in shaping the world landscape in terms of economic growth, urbanization patterns, and population increase (Fujita & Mori, 1996).

A renaissance may be particularly true in many Asian countries where a large share of the population and economic activity has concentrated in port cities (Merk, 2014). In these city cases, there is a twofold objective to maximize production output while at the same time minimizing international trade and transportation costs. Indonesia, China, Singapore, Thailand, and South Korea have all developed a solid network of port cities that are able to fulfill international trade demands and the import/export of semi/final manufactured goods (Feng, Mangan, & Lalwani, 2012). In the case of Asia, port cities are not only departure cities from the point of view of manufactured goods, but they are also arrival cities for investment flows and the labor force (Saunders, 2012).

In fact, port cities are dynamic and vibrant places where many people relocate in order to find new opportunities or to simply start a new job. Given that the real estate market is the first responsive variable to a change in the level of investments or population (Crowe, Dell'Ariccia, Igan, & Rabanal, 2013), port cities are exposed to sudden shifts in demand for housing or business properties. Sudden changes might be driven by high expectations or excessive exuberance in regard to future performance of the port city itself. However, speculative effects in port cities can also be triggered by economic policy implemented at regional or national level.

Research has shown that port cities leverage their success on the demand for foreign goods, either imported or exported (Merk, 2013). In particular, according to neoclassical theory, production activity is organized around efficient ports whose only aim is to be closer to the export of manufactured goods or the import of products and semimanufactured goods from other countries (Schweizer & Varaiya, 1997). The political agenda of many Asian countries has thus followed suit; for many years they have focussed on raising the levels of international trade to boost regional and national economies, increase the efficiency of port cities and attract further business development. A wide array of policy tools has been implemented to develop port cities, attract investment and support local economic growth, including in some instances, special economic zones combined with tax relief and tax breaks for foreign or local investments. A well-known example is provided by the FEZ; FEZs are specially designed zones which aim to encourage foreign investments by improving the living, management, and business environments of the host region for foreign-invested firms.

A FEZ can be considered as the ultimate frontier of market deregulation in which special districts are created in order to attract business and thus generate long-term growth and economic benefits. However, when a market suddenly becomes unregulated or liberalized it can be subjected to speculative investment provoked by an over-estimation of future economic growth. In these particular cases, speculation tends to affect the real estate market which, in port cities, is generally highly dynamic.

Speculation can act like a large clump of sand in the gears of the economy; it affects asset values by distorting prices, creates capital allocation inefficiency across markets, and undermines both the economic and financial stability of a system, economy, or region (Bernanke, 1983). Furthermore, speculation fuels over-expectations regarding future asset returns, over-heats the investment decisions and inverts prices from their actual fundamental values (Case & Shiller, 2003). In the particular instance of the real estate market, speculation refers to the purchase of real estate assets in order to obtain capital gains rather than enjoying the benefits derived from it, thus instigating the inefficient allocation of the resource and a distortion in the level of prices (Kaldor, 1939). We would therefore suggest that the speculative drawbacks in port cities can undermine the benefits generated by fiscal policies such as FEZs.

Research confirms that speculation in the maritime industry arises from multidimensional factors (Cocconcelli & Medda, 2016). However, there is still no agreement on the main determinants and the causality relationships that instigate speculative behaviors at regional level, and in particular in port cities and their real estate markets. Speculative behaviors have been shown to occur from a spectrum of macroeconomic causes and microeconomic interactions. The macro approach recognizes market inefficiency and monetary conditions as the primary causes of speculation (Mises, 2006), whereas a second stream of research emphasizes psychological factors and agent expectations as the main causes of boom and bust cycles (Akerlof & Shiller, 2009). In this context, some economists have emphasized the outstanding role of public policies in creating distortions and over-heating the investments in some sectors of the economy. This is particularly true in the case of South Korea. Kim and Soo (1993) demonstrate that a bubble existed in South Korea from 1974 to 1989, which was mainly caused by fundamental factors such as interest rates and money supply. According to this view, the Korean boom and bust cycle was fulfilled by foreign investors who had been attracted by a wide plan of market liberalization and loose exchange rate policy.

In recent years, other Asian countries, such as South Korea, have experienced rapid growth in their economies, prompting concern about sustainable long-term development, over-heating of the investment environment and the correct pricing of assets. As depicted in Fig. 12.1, between 2004 and 2010, South Korea underwent a long period of fast expanding economic growth where the gross domestic product increased by 6% on average. Interestingly, during the global financial crisis, South Korea over-performed in relation to Western economies and was able to deliver an outstanding pace of growth which was driven primarily by its international trade-oriented role in the region.

According to the World Bank, South Korean GDP was US$1.163 trillion in 2011, with an economy that relies largely on international trade. The main economic indicators for 2011 show that exports accounted for 43.7% of GDP, while imports were at 40.2%; these two numbers provide an impressive total trade to GDP ratio of 83.9%. Given an economy deeply reliant on international trade, both the maritime industry and efficient port activity are vital to South Korean growth objectives.

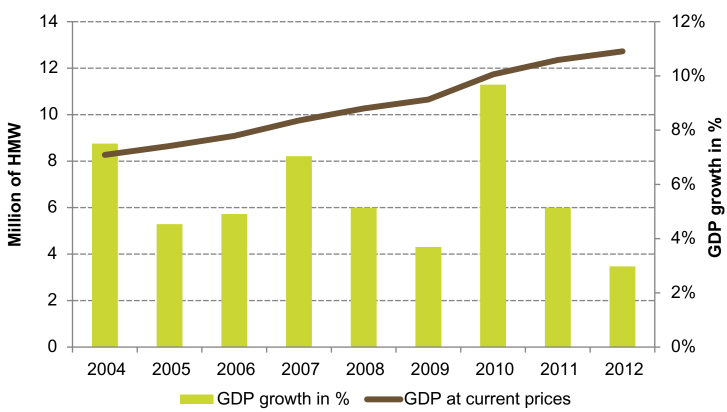

Figure 12.1 South Korea GDP: real values and % growth. *From South Korean Central Bank.*

In order to further revive international trade, boost the level of investments, and increase attractiveness to foreign investors, South Korea launched an ambitious program of regional policies in August of 2003, to create FEZs in particular in port cities. According to the South Korea Committee for FEZs, their core set of objectives is achieved through the provision of a comprehensive legal framework, tax benefits, financial incentives, deregulation, and guidance to firms and businesses that want to locate in South Korean FEZs. Across the country, the Committee has identified five strategic economic zones as the foundation cities for developing FEZs: Incheon, Busan, Gunsan, Daegu, and Ulsan (see Table 12.1).

For 15 years, the construction and implementation of FEZs has been one of the most outstanding developments in South Korean regional policy; these multidimensional policy tools not only promote foreign investments but also draw together a comprehensive plan for revitalization, redevelopment, and refurbishment of urban areas and infrastructure surrounding the FEZs. For example, the first FEZ-designated area in Korea, the Incheon Free Trade Zone (August, 2003), has delivered on the 169 km^2 area the redevelopment of Incheon International Airport, Incheon Port and the Songdo, Yeongjong, and Cheongna neighborhoods.

This comprehensive modernization plan, via FEZ implementation, has instigated a wave of investments in port cities by targeting real estate assets in particular. The Korean Government selected Incheon FEZ as a global business outpost promoting free economic activities. Although arguably effective at the outset, the plan is now developing into the construction of an international urban central hub and poses serious consequences for the real estate markets of the cities. The implementation of FEZs has been followed by a marked and rapid expansion in real estate

Table 12.1 FEZs in South Korea

District	Focus industries	Starting date
Incheon FEZ	IT, BT, international finance, tourism, and leisure	2003
Busan FEZ	Maritime logistics and shipbuilding	2004
Gunsan FEZ	Automobiles, shipbuilding, and green industries	2008
Daegu FEZ	Education, medical and knowledge-based	2008
Ulsan FTZ	Manufacturing industry (automobiles)	2009

Source: fez.go.kr database.

prices. As shown in Fig. 12.2, between 2005 and 2010, the South Korean real estate market peaked and prices increased sharply, slowing only after the recession of 2010.

As observed in Fig. 12.2, the South Korean real estate price index experienced steady growth of more than 5% per year. In recent decades this pattern has taken the form of speculative investments (Ha, 2010). In particular, after FEZ policy was implemented, real estate prices skyrocketed and between 2005 and 2010 the price growth took the form of speculative investments. Expectation for the success of FEZ policy, in addition to the increase in international trade, boosted demand for real estate assets; real estate prices began rising suddenly because economic agents expected a boost to Korean international trade and business relocations to major port cities. In fact, according to data from the South Korean Central Bank, the house price index leaped dramatically to a 20.8% increase on a year-on-year basis. However, the cycle terminated rather abruptly when the global financial crisis bumped into the Korean economy in late 2007. The remarkable real estate price slow-down led to bankruptcies in construction companies and high numbers of foreclosures resulted in a steep increase in perceived credit risk. As Fig. 12.3 shows, the Korean index for credit risk peaked to its maximum level in the first months of 2009, with the main risk factors coming not from banking institutions (as mostly happened in the rest of the world), but rather from households and small and medium enterprises. The increase in the perception of risk prompted upward interest rates, borrowing costs and reduced refinancing strategies for borrowers. Therefore, the business cycle

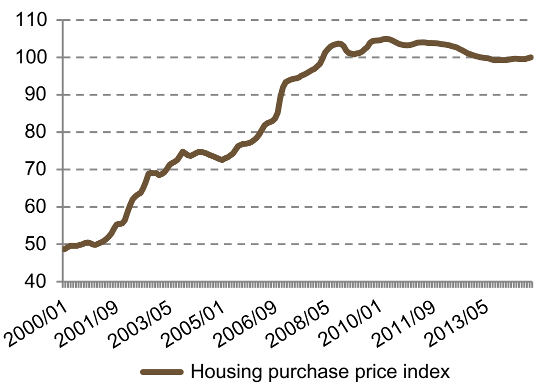

Figure 12.2 South Korean real estate price index (inflation-adjusted). *From South Korean Central Bank.*

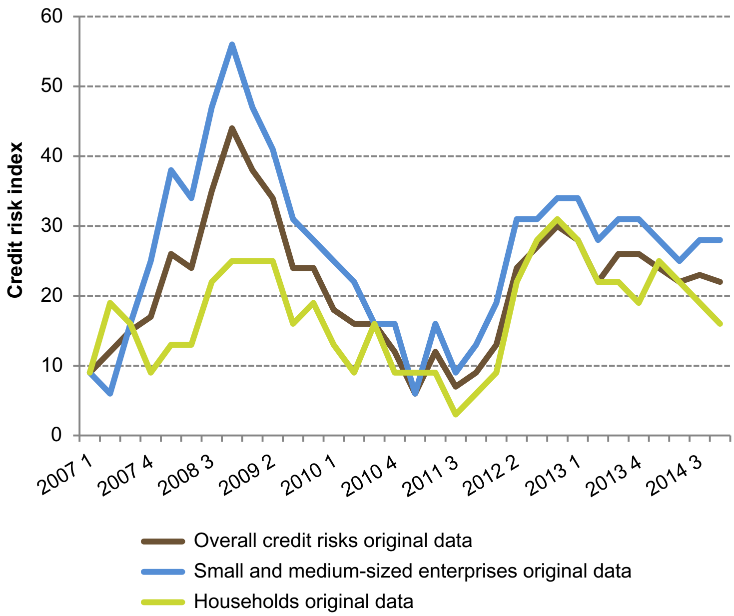

Figure 12.3 South Korean credit risk index. *From Korean Central Bank.*

contraction was amplified by the speculation in the real estate market. The boom and bust cycle in the Korean real estate market was even more pronounced in the case of FEZ port cities. In the next section we demonstrate that the over-expectation created by an increase in international trade and foreign investments prompted a super cycle that was particularly exacerbated in the case of Port Cities hosting a FEZ.

12.3 CASE STUDY SELECTION, METHODOLOGY AND DATA

In order to capture the relationship between real estate behaviors and port features, we compare the performance of South Korean FEZ ports to their real estate market performance and regional economic indicators. The cities we have included in this research are Incheon, Ulsan, and Busan. Although these cities have the common characteristic of strong economic expansion between 2004 and 2012, many differences arise in their productivity contexts and main features of their local ports. Traditionally, Busan, South Korea's largest port city, has been an important center for manufacturing production and exports. After 2008, however, the well-established leadership of Busan has been nearly matched by the fast-growing cities of Ulsan and Incheon. Incheon in particular expanded rapidly between 2003 and 2014, thus bridging the gaps differentiating it from Ulsan and Busan (Fig. 12.4). Incheon's rapid growth derives from the development of a new port and the creation of a new and dynamic FEZ in 2003. The same pattern can be observed for Ulsan; upon its FEZ inauguration in 2009, the city experienced an economic surge that brought its GDP very close to the group average after many years of stagnation.

Although the cities included in the study share these common economic characteristics, the context of the ports and their own core activities differ. Not only is Busan the largest port city in South Korea, but it also represents a national hub in terms of exports. Moreover, Busan's metropolitan region is considered as a prominent cultural, economic, and educational center and represents a "gateway" into the whole country (see Fig. 12.5). Incheon is the third most populous city in South Korea (after Seoul and Busan) whose growth is boosted by the development of a "multipurpose" port that benefits from its proximity to the South Korean capital. As Fig. 12.5 depicts, it is particularly true for Incheon that the core activities of the Incheon port focus more on costal shipping than in Ulsan and Busan. Finally, Ulsan represents an interesting example of having a "specialized" port; the production context of the city (mainly reliant on heavy industry) has contributed to the further development and specialization of the city's hinterland in addition to Ulsan core port activities. It is noteworthy that Ulsan is the headquarters of Hyundai Heavy Industries, the largest shipbuilding company in the world. Hyundai has

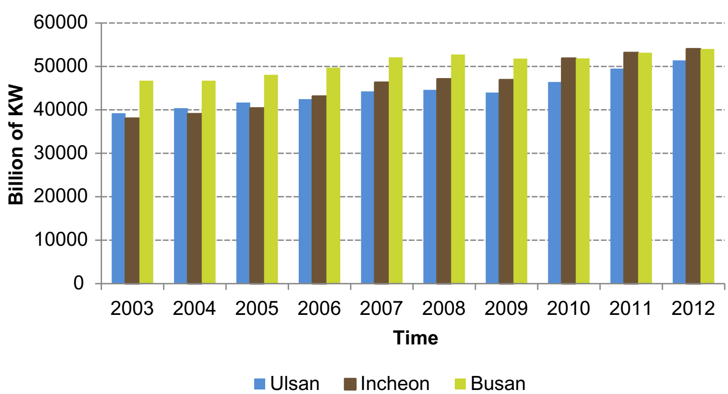

Figure 12.4 Ulsan, Incheon, and Busan GDP. *From South Korea Central Bank database.*

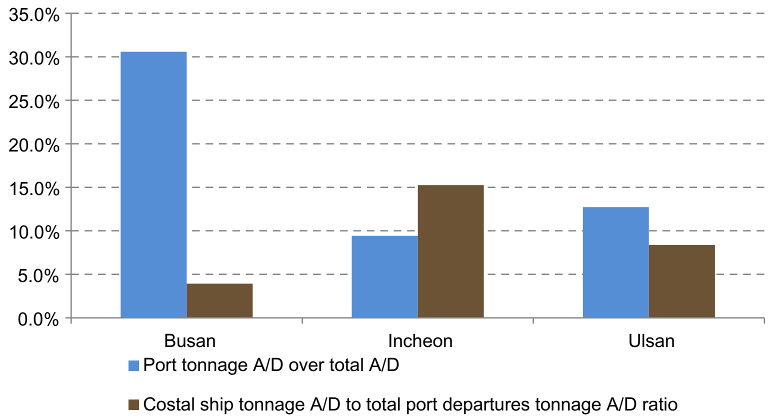

Figure 12.5 Port characteristics for Busan, Incheon, and Ulsan. *From fez.go.kr database.*

developed a long-term collaboration with Siemens to provide cutting edge technologies for shipbuilding and has invested heavily in the modernization of Ulsan shipyards and the surrounding port area (Vladimir, 2012).

In our three study cities FEZ cities are characterized in the following way:

- *Gateway*: ports are inextricably linked to an economic and socially strong territory, such as a city ~ *Busan*
- *Multipurpose*: ports mainly engage in cargo transhipment and are thus almost wholly dependent on relay and feeder activities ~ *Incheon*
- *Specialized*: ports rely on the performance of a core industry located in the city ~ *Ulsan* (Fig. 12.6)

In our selection of case studies, the aims of the analysis are threefold:

1. Evaluate whether or not the performance of the real estate market is in line with the main economic indicators of city economies;
2. Assess whether there are significant differences in risk perceptions between FEZ real estate performance in relation to the gateway, multipurpose, and specialized ports.
3. Verify whether the presence of FEZ creates a leapfrogging effect in the real estate market.

In the present analysis we assume that real estate is a perfectly competitive market, with well-informed economic agents who buy and sell real estate assets. We also assume that real estate price fully incorporates the information available in the market. We proffer these assumptions in

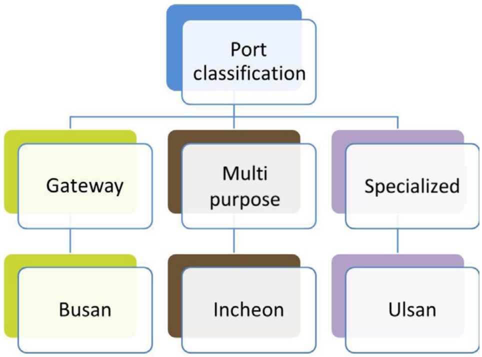

Figure 12.6 South Korean port classification.

Table 12.2 Key South Korean regional economic variables included in the study

Regional economic	Real estate	International trade	Port
Employment GDP (real prices) Foreign direct investments	Land prices Commercial values Residential values	Total exportations Total importations	Number of berths Number of TEUs traded

order to tackle the problems of liquidity and asymmetry of information which could otherwise distort the final conclusions of this chapter.

Under these assumptions there are no arbitrage gain possibilities; housing and the main regional economic variables are therefore expected to follow the same trends.

Our study draws from a dataset comprising several regional economic variables, city real estate market prices, port characteristics, and merchandise trading volume per city. The data for the empirical analysis is regional and represents the same unit level (city). Data sources for the analysis are the Korean Central Bank and Real Estate Office. According to the IMF world economic outlook of 2004, the main regional variables linked to the growth in real estate prices are identified and listed in Table 12.2.

The motivation behind the inclusion of the regional economic variables in the dataset coincides with three requirements essential to this part of the research. First is data reliability, which points to a certified statistical office that collects these data; second is time and space consistency, which means that the data has the same sample size and same collection methodology across the country; and third is availability, which means that the data are fully available for the cities included in our study. Furthermore, these variables play a remarkable role in the identification of the economic performance of cities (Spencer, Vinodrai, Gertler, & Wolfe, 2009), growth trends in port activity, regional economics (Coppens, et al., 2007), and speculative behaviors (Pan & Wang, 2013). By presenting some background information, we underpin the multidimensional aim of this chapter and shed light on the economic dynamics of the main cities under scrutiny. In Section 12.4, we deliver a model regarding speculative investments for each objective of the research; thereafter, we test our study variables according to this framework, and lastly, discuss the results of our estimations.

12.4 DATA ANALYSIS AND RESULTS

We can now specify a model to test the system of three hypotheses set up in the introduction of this chapter, where real estate price is defined as a function of the main economic variables of the port city:

$$P_t^* = f(r_t, RF_{t,t-1}^*), \tag{12.1}$$

where P_t^* is the real estate price; r is a vector containing the main regional economic variables; $RF_{t,t-1}$ is a matrix containing the lagged variables of real estate prices and the main regional economic indicators.

Nearly 30 years ago, Stiglitz warned that "...if the price is high today it is only because investors believe that the selling price will be high tomorrow—when "fundamentally" it does not seem to justify such a price—then a bubble exists" (Stiglitz, 1990). According to this definition, a positive correlation is expected between real estate prices, city GDP, foreign direct investment, and level of employment. The increase in GDP should be followed by an increase in real estate prices and the same relationship should be verified in the case of FDI and employment. Therefore it is possible to test for a long-term common trend between the regional variables under scrutiny and the level of real estate prices. If the relationship does not hold it means that real estate prices are behaving differently from the underlying economic factors. In this case we can assert that a distortion is taking place in the market in the form of speculation.

$$P_t = RF_{t,t-1}^* + B, \tag{12.2}$$

where P_t is the price of real estate inflated by the speculative component; $RF_{t,t-1}$ is a matrix containing the lagged variables for real estate prices in port cities and regional economic factors; B is the speculative expectation regarding the future increase in prices.

In other words, if the bubble components converge towards zero, real estate prices and their fundamental values converge; whereas, if the bubble component is increasingly expanding, the price of real estate diverges from its normal rate of growth given by the economic fundamentals. In this case, the hypothesis of speculation can be confirmed. In order to test the presence of speculative bubbles in Korean port cities and differences between port city characteristics, the real estate prices in our test case, South Korean cities, follow the regional economy fundamentals. A cointegration analysis is carried out between the real estate prices and regional factors matrix (Engle & Granger, 1987). The cointegration analysis evaluates whether real estate prices and the set of regional economic variables maintain a long-run equilibrium. The two variables are cointegrated if: (1) they are integrated of the same order, or (2) there is a stationary linear combination of the two variables (Johansen, 1995). We wish to determine whether the cointegration test evaluates if the FEZ real estate prices component shares the same trend as the other main economic indicators of the region. If this relationship does not hold in accordance with the model, this means that speculative pricing is affecting the real estate market in the region. The capital city of South Korea, Seoul, is also included in the analysis in order that we may provide a broader picture of the economic situation, compare results with a benchmark and further investigate the patterns unveiled by the empirical tests.

In Table 12.3, the results of cointegration tests and the P-value statistics are presented for each city under scrutiny. The tests for Ulsan (which, according to the classification system used, is a specialized port city) show that all the main economic regional indicators are cointegrated with real estate prices. This evidence demonstrates that a specialized port is more connected and linked to the performance of the regional economic system and is therefore less prone to boom and bust cycles. According to this test, the fluctuations in business cycles for specialized ports are not amplified in magnitude by a very leveraged and speculative real estate cycle; therefore the stability of FEZ policy and the regional economy are enhanced. However, these results are in contrast with the test findings for the city of Seoul, where all the main variables exclude correlation with real estate prices. These findings might be caused by the grouping of the

Table 12.3 Cointegration analysis and test results for South Korean cities

City	Testing variables	Rank	L_{max} test	*P*-value
Seoul (capital city)	Real estate vs employment	0	10.022	0.0913
		1	0.46579	0.2049
	Real estate vs FDI	0	3.5166	0.8974
		1	0.025238	0.8738
	Real estate vs city GDP	0	74.133	0.0000
		1	4.9376	0.0263
Incheon (multipurpose port—FEZ)	Real estate vs employment	0	7.3110	0.4618
		1	0.21815	0.6405
	Real estate vs FDI	0	5.6340	0.6647
		1	0.21096	0.6460
	Real estate vs city GDP	0	11.002	0.1561
		1	1.8337	0.1757
Busan (gateway port—FEZ)	Real estate vs employment	0	12.489	0.0931
		1	0.44088	0.5067
	Real estate vs FDI	0	NA	NA
		1		
	Real estate vs city GDP	0	10.597	0.0785
		1	1.1696	0.1795
Ulsan (specialized—FEZ)	Real estate vs employment	0	16.996	0.0161
		1	0.52669	0.4680
	Real estate vs FDI	0	NA	NA
		1		
	Real estate vs city GDP	0	216.26	0.0000
		1	13.388	0.0003

data, which excludes differences at city level, such as social patterns at council level, economic growth of neighborhoods, and market segmentation in the capital city. In fact, these patterns are quite spread out in large capital cities where a diversified population lives and works; as was verified among developed countries (London, Paris, New York) and among emerging market countries (Brasilia, Cape Town, Moscow, and New Delhi).

On the other hand, in the Incheon test result (a multipurpose port), we find a significant difference between the growth of the economy and real estate prices. As its *P*-value confirms, there is a lack of cointegration between real estate prices and GDP, FDI and employment rate. According to the assumptions of Section 12.2, the growth in the Incheon real estate price is detached from the other economic fundamentals, and in some cases this effect exacerbates fluctuations in the business cycle, thereby leading to periods of speculative investment. Additionally, the results for Incheon are in line with the Seoul analysis; both cities' real estate markets have developed a different growth pattern between prices and regional economic fundamentals. In the capital city and multipurpose port city we can verify driving forces that are pushing real estate prices away from the regional economic development process.

However, if in the capital city of Seoul, social, economic, and real estate characteristics can bias the final estimation of the test, the same is not true for Incheon. The underlying economy of this multipurpose port city is leading the changes in real estate market and employment patterns, thus exposing it more directly to business cycle upturns and downturns. In fact, the data analysis suggests that multipurpose ports can experience periods of speculation due to their inherent transhipment role; the increased demand from different parts of the country drives up the location attractiveness and generates exuberance in the regional economy and over-heating property prices. Following Do (2012), speculation in the Incheon real estate market poses serious problems for the sustainable development of FEZs and the Incheon economy. Along with a leveraged real estate market, Incheon speculation has driven gentrification in many of the city's neighborhoods; parts of the city are witnessing a gradual flight of the preexisting residents (mostly low income) to the nearby vicinities where land is cheaper (Do, 2012). The significance of these results is confirmed in the second stage of our analysis.

The second step/hypothesis of the analysis focuses on real estate volatilities in our three-city analysis. Here, we compare the volatilities of real estate prices in order to assess if significant differences are present in the risk perceptions of FEZ real estate performance in relation to gateways, multipurpose and specialized ports. In our study, the volatility is calculated as the variance of the monthly returns of real estate prices for each city. The results of the test are provided in Table 12.4, where critical values and associated *P*-values are shown in brackets.

The results show that Ulsan has a different growth pattern when compared with the other cities. If the variance is used as the main indicator of risk for real estate (Cocco, 2000), it is possible to conclude that Ulsan is the only city that has developed a less risky market, while Incheon presents the higher risk in the data sample. Combined with the former analysis, these results might indicate that a more resilient environment against speculative investments may be found in specialized ports, whereas in multipurpose ports evidence indicates that a riskier growth and

Table 12.4 Results for ANOVA tests

***F*-statistic (*P*-value)**	**Seoul**	**Incheon**	**Busan**	**Ulsan**
Seoul (capital city)	//			
Incheon (multipurpose)	319.109 (0.00087)	//		
Busan (gateway)	306.535 (*6.47668E-11*)	6.885 (*0.031972*)	//	
Ulsan (specialized)	526.147 (*1.66513E-12*)	13.698 (0.320405)	3.960 (0.564485)	//

speculative effect can develop. Nevertheless, we must point out that the volatility of real estate prices is highly correlated with the supply and demand elasticity; the less elastic the supply is, the larger the price volatility will be (Malpezzi & Wachter, 2002), thus leading to biased estimations. Overall, it is possible for us to conclude that, although Incheon witnessed a real estate growth detached from its local economic fundamentals, the market presented a higher level of risk which was not connected to the nature of the port city itself. The multipurpose port should be more resilient to economic shocks than specialized ports because of the nature of goods delivered; these are more diversified, thus providing a cushion during periods of economic downturn. This conclusion leads us to the possibility that other forces have driven the volatility in the market, and among those, speculation is the main suspect. In fact, speculation affects the normal variability of prices; while in upturns it provides a safe high return with low variability, but in downturns the price fluctuations are exacerbated, thus leading to higher volatility.

Following the findings of the former tests, it is necessary to evaluate the performance of real estate prices in respect of the distance to the FEZ district. In our third step of the analysis we want to verify whether the presence of FEZs creates a leapfrogging effect in the real estate market and obtain a quantitative measure of how prices decay with respect to the FEZ. We wish to understand why some urban areas experience a jump in real estate prices, noncontiguous city development and possible gentrification, urban sprawl, and segregation. The leapfrogging effect disallows urban policies to provide sustainable urban development; when this effect occurs, it is nearly impossible to promote compact and contiguous development patterns in order to efficiently provide public services across the city.

We have evaluated the performance of the real estate prices in each of our study city districts. The first data analysis provided in Fig. 12.7 plots the real estate prices and the relative distance from the FEZ. At first sight, the picture reveals different "types" of price decay from the FEZ; in the case of Incheon, the prices decay rapidly and present some spikes. However, in Ulsan and Busan, prices tend to slowly and constantly decrease with the increase of distance to the FEZ. The peculiar aspect of the whole picture relates to the jumps witnessed in Incheon, in which a discontinuity in the decay function provides some interesting patterns of urban sprawl and leapfrogging effects.

As previously mentioned, although the phenomena for Incheon indicate an improved quality of life, they nevertheless represent a primary cause of the gradual flight of the preexisting residents, of mostly low income, to nearby vicinities where real estate price is cheaper (Songdo Development). However, as the charts in Fig. 12.7 show, it is still necessary to quantitatively identify the effect of FEZ distance on prices. These patterns suggest the presence of a nonlinear relationship between our two

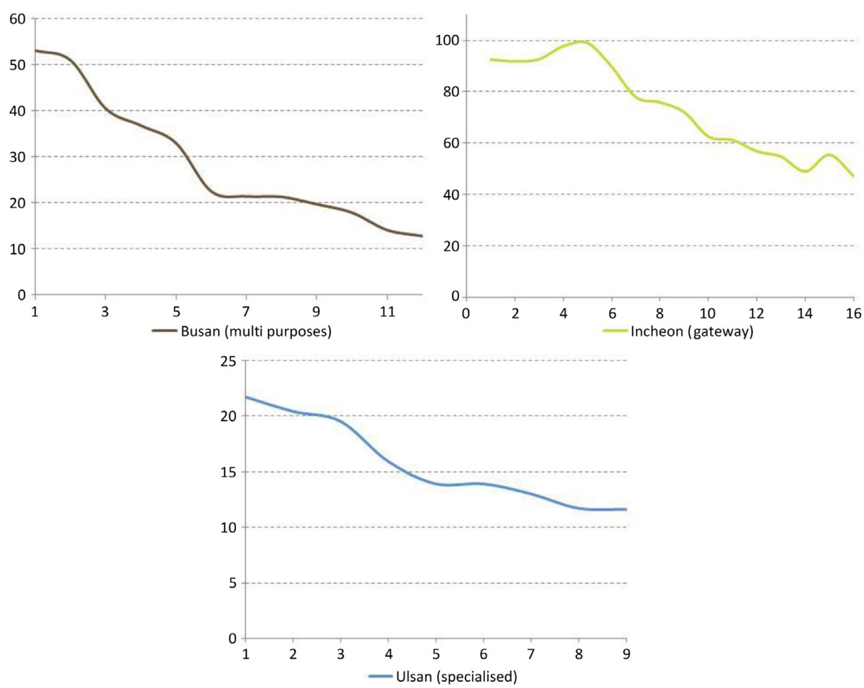

Figure 12.7 Real estate prices ranked according to distance from FEZ.

main variables of interest in this analysis. Therefore in order to assess the responsiveness of prices to changes in distances from the FEZ, we specify a nonlinear equation that considers the price decrease as a negative exponential function of the distance to the FEZ district. The equation takes the following form:

$$Y_t = A_t X_t^{-\alpha} \varepsilon_t \tag{12.3}$$

where Y_t is the dependent variable at time t; A_t represents the intercept of the regression; $X_t^{-\alpha}$ is the independent variable at time t; α is the parameter that plays the pivotal role in the analysis; ε_t is the error term of our model; it is normally distributed and its average is equal to zero and has constant variance.

In order to estimate the parameter α, we conduct a nonlinear ordinary least squares estimation in line with the work of Bates and Watts (1988). The analytical results are given in Table 12.5.

The outcome of the nonlinear regression indicates that the Incheon alpha parameter is negative and is the smaller of the samples under analysis. In Incheon, results show a high negative dependency of prices in relation to distance from FEZ. Yet, despite this parameter, the fastest growing FEZ districts in Incheon are also increasing their importance within the city network and are expected to create a predominance that precipitates more inequality within the city boundaries. However, the opposite situation is verified in Ulsan and Busan, where the parameters are larger and indicate a higher elasticity of prices with respect to FEZ distance. The fact that the parameters diverge so much draws our attention to the speculative issue. We may, to some extent, consider that resiliency to speculation is nested within increasing flexibility; as a price buffer provides more and more opportunity to escape from sudden supply and demand changes, it is less likely that we will witness speculative patterns and boom and bust cycles.

Table 12.5 Results of the regressions grouped by city

	Incheon (multipurpose)	**Busan (gateway)**	**Ulsan (specialized)**
Constant (*P*-value)	4.635 (*−9.57E-12*)	4.132 (*1.09E-10*)	3.156 (*1.59E-11*)
Alpha (*P*-value)	−0.033 (*0.011*)	−0.139 (*1.05E-05*)	−0.085 (*1.05E-05*)
R-squared	0.62	0.94	0.95
S.E. of regression	0.076	0.096	0.056

12.5 DISCUSSION AND CONCLUSIONS

The dataset employed in this research consists of a vast and multidimensional collection of economic and financial variables gathered from South Korean real estate authorities, the South Korean Central Bank and the Statistics Office. The period of investigation ran from May 2003 to December 2013, yielding a total of 400 observations. Given our focus on the study of port characteristics and real estate speculative investments, we have in this chapter employed the monthly dataset extensively in order to test: first, whether or not the performance of the real estate market is in line with the main economic indicators of a city economy; second, if there are significant differences in risk perceptions between FEZ real estate performance for the gateway, multipurpose, and specialized ports; and third, whether the presence of FEZs creates a leapfrogging effect in the real estate market.

The analysis was based on three econometric and statistical tests. We first tested the cointegration between real estate prices in the gateway, specialized and multipurpose ports with the main economic regional variables. In the second analysis, a test on the variance was employed in order to confirm whether or not the real estate market risk is significantly different in our study cities. Finally, in the third part of the analysis we used a nonlinear regression to verify the existence of different decay functions in South Korean port cities.

We can summarize our main results as follows. We tested for the presence of speculative bubbles in the cities, such as Seoul, Busan, Ulsan, and Incheon. Our findings suggest the presence of speculative behaviors, most notably in Seoul and Incheon (multipurpose port). The test of the variance within real estate prices of the cities indicates that Incheon real estate price volatility was significantly higher during the period under scrutiny, and shows that only the city of Ulsan has developed a more resilient price growth. In the final step/hypothesis of the analysis, the decay function of prices from the FEZ district analysis provides further evidence for the different behaviors of port city real estate markets. We can point to a significant finding for Incheon, which shows an irregular pattern of real estate prices, and thus raises concern about possible leapfrogging effects. Second, the elasticity of price changes was quantified to the FEZ distance; results indicate that the city of Ulsan shows a less steep decline from the FEZ district, providing evidence for a harmonious development of real estate prices.

The results obtained in this chapter may spark interesting policy discussions on regional economic growth management. This study has confirmed the presence of speculative behaviors in South Korea and FEZ cities. In particular, speculative effects are likely to occur when the FEZ is connected to a multipurpose port, as in the case of Incheon. Korean regulation on speculative practices has not considerably enhanced real estate stability. In addition, FEZ policy has a major effect on real estate in areas where ports are specialized (Ulsan). It is possible to conclude that the FEZ plays a pivotal role (dynamo effect) for local development by enhancing regional attractiveness, competitiveness, and agglomeration. Nevertheless, since speculation undermines the regional benefits generated by the implementation of FEZs, in order to achieve effective impacts on the regional economy, FEZs should be tailored to the characteristics of each port area.

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CHAPTER 13

Risk Management in the Airline Industry

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13.1 INTRODUCTION

Firms operating in the airline industry face massive risks, from fluctuations in the price of jet fuel to macroeconomic swings and changes in government regulations. New aircraft require massive capital outlays. A major cost for airlines is jet fuel, and in the past 15 years, the price of fuel has fluctuated wildly, creating huge gains and huge losses. Furthermore, changes in the global economic environment lead directly to volatility in passenger demand, while government regulations and tax policies can depress profits.[1] Airlines that operate in multiple countries also face exposure to currency exchange risk. If these risks are not enough, there is always the threat of new competitors in the form of low-cost airlines or global airlines competing on new routes. It is no wonder that many airlines have gone through bankruptcy or been acquired. Indeed, Gong (2007) notes that between deregulation of the US airline industry in 1978 and 2006, about 160 carriers had filed for bankruptcy protection.[2]

How do the airlines manage these enormous risks? At a corporate level, major airlines explore mergers and acquisitions, code sharing, and subcontracting their lesser-traveled routes to regional players. In the finance area, many airlines hedge fuel costs and currencies, and they employ numerous lease options to reduce the risk associated with huge

[1] Harper (2017), for instance, quotes the director general of the International Air Transport Association (IATA), Alexandre de Juniac, as stating that "government politics and actions come between [ALTA member airlines'] efforts to run strong business and sustainable levels of profitability."

[2] Interestingly, these airlines, and their competitors, saw significant positive stock prices changes after the filing, while their competitors also saw significantly positive changes at the time of the filing.

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capital outlays. At an operational level, they adjust capacity by changing flight frequencies and aircraft size. Finally, in the pricing area, they work with sophisticated revenue management tools to maintain high load factors and maximize expected revenues. It is our observation that airlines make decisions on capacity, hedging, and pricing in different functional silos, rather than in an integrated way. This chapter addresses risk management in the global airline industry, with the goal of creating a better understanding of their management of each type of risk, and ultimately advancing the ability of the airlines to manage risks in a truly integrated way. Section 13.2 briefly reviews the relevant literature. Section 13.3 explores the risks the airlines face and the tools they use to manage them. Section 13.4 then highlights some of our own empirical research, while Section 13.5 introduces a framework for an analytical model for integrated risk management in this industry. Section 13.6 provides a summary.

13.2 LITERATURE REVIEW

Because overall demand for airline travel is critical to every carrier, researchers have devoted significant energy to estimating the effect of various factors on airline passenger demand. These include service-related drivers, such as airfare, flight frequency, aircraft size, and load factor, all of which are under the control of the airlines. Other factors, which are outside the airlines' control, include the state of the economy, competition, and fuel cost. See, for example, Douglas and Miller (1974), Jorge-Calderón (1997), and Chi and Baek (2013). In this stream, Fridström and Thune-Larsen (1989) developed a direct demand intercity gravity model to forecast air traffic demands on Norway's network. They relied on cross-sectional and time series data on traffic flows, fares, travel time, income, and population to estimate the demand for flights. Wei and Hansen (2006) examined a hub-and-spoke network and explored the impact of flight frequency, aircraft size, airfare, flight distance, and socio-economic conditions. Wei and Hansen (2005) examined total passenger demand and airline market share in nonstop duopoly markets. The factors they studied were aircraft size, flight frequency, airfares, and seat availability, and they concluded that airlines gain more market share by increasing flight frequency than by increasing aircraft size. Ito and Lee (2005) examined the impact of the September 11 terrorist attacks on US airline demand. Using monthly cost of jet fuel as a proxy for airline supply, they showed no significant statistical relationship between jet fuel price and airline demand. Other research in this general area includes Franke and John (2011), Pearce (2012), Chi and Baek (2013), Barrett (2004), and Pels, Njegovan, and Behrens (2009).

Fuel cost is clearly of critical importance for the airlines, typically ranking first or second in operational costs. According to the airlines' 2014 10-K forms, fuel cost accounted for between 10% and 45% of total expenditures from 2003 to 2013. This striking range is primarily a result of fuel cost fluctuations, which are due to a number of factors, including government policies, inventory, political issues in oil-producing regions, and imbalances in the supply–demand relationship. Indeed, it is exceptionally difficult to forecast fuel prices. Relevant research on fuel costs in the airline industry includes Ryerson and Kim (2014) who studied fuel consumption and airline mergers. They found that mergers reduced flight frequency and nonstop flights, while increasing economies of scale at the hubs. The effect was decreased fuel consumption. Ryerson and Hansen (2010) examined three types of aircraft, and using an optimization model showed that the optimal fleet mix is highly sensitive to fuel prices and passenger costs. In their paper, passenger costs included schedule penalties, preferences for jets over turboprops, and travel time costs. Borenstein and Rose (2008) studied volatility in earnings as a function of fluctuations in fuel cost and passenger demand, among other factors. They found that, because of competition and logistical complexities, the airlines are hesitant to change flight schedules in response to fuel price fluctuations. They also found that sudden swings in fuel price do not play a major role in load factors. Borenstein (2011) later found that fuel costs were a key factor in airlines' earning fluctuations, but the research was limited to 2007–09. See also Hsu and Eie (2013), Hsu and Wen (2002), and Chao and Hsu (2014). The latter paper developed a model for aircraft types and air cargo routes and revealed that optimal payloads for different types of aircraft vary with fuel price fluctuations.

Airlines must balance maximizing profits with service quality. Airlines maximize profits, for instance, by keeping load factors high, and if necessary, reducing capacity by decreasing flight frequency and aircraft size. Yet these very decisions can lead to customer dissatisfaction and a perception of lower service quality (Carey & Nicas, 2015). A number of research studies thus examine flight frequency, aircraft size, and network configuration relative to the demand–supply equilibrium. For instance, see Swan (1979), Teodorovic and Krcmar-Nozic (1989), Hsu and Eie (2003), Givoni and Rietveld (2009), Givoni and Rietveld (2010), Pitfield, Caves, and Quddus (2010), Takebayashi (2011), and Zou and Hansen (2012). Pitfield et al. (2010) employed a three-stage least squares model to evaluate the interaction between flight frequency, aircraft size, and the total number of passengers traveled in a market. They used pooled time series cross-sectional data on North Atlantic routes, and they found that increases in demand are associated with larger aircraft and increased flight frequency. See also Pitfield, Caves, and Quddus (2012). Wei and Hansen (2003) formulated a model of aircraft cost and size, and learned that economies of scale exist in both aircraft size and stage length.

Many airlines employ financial instruments such as hedging and derivatives to deal with fuel cost uncertainty and fluctuations. Because jet fuel contracts are not available in commodity markets, airlines usually establish contracts on kerosene, crude, or other oil products. A number of contracts are possible from swaps and forward buys, to futures and options. The literature on hedging is extensive; see, for example, Rampini, Sufi, and Viswanathan (2014), Adams and Gerner (2012), Carter, Rogers, and Simkins (2006), and Treanor, Rogers, Carter, and Simkins (2014).

A useful overview of operational risks and the use of financial hedging in managing these risks is provided by Van Mieghem (2012). Ding, Dong, and Kouvelis (2007) studied the integration of operational and financial hedging by considering an international corporation, not necessarily an airline, facing both domestic and foreign demand risks, along with currency exchange risk. They solved a mean–variance problem that allowed for one-shot hedging using currency exchange options to mitigate the price risk in foreign markets. Shantia, Aflaki, and Ghoddusi (2017) examined the interaction between financial hedging and technology improvements that reduce the use of a production input that has volatile pricing. An example of the latter is new aircraft that consume less fuel. See also Van Mieghem (2007), Chod, Rudi, and Van Mieghem (2010), and Wang and Yao (2017). Berghöfer and Lucey (2014) examined both financial and operational hedging strategies for airlines in the United States, Europe, and Asia. They analyzed 64 airlines across an 11-year time period and found that Asian carriers were more negatively exposed to fuel price risk than European airlines, but less exposed than North American airlines. They defined operational hedging as using fleet diversity, which can be accomplished by employing either different aircraft types or different aircraft families. They found that neither financial nor operational hedging significantly reduced risk exposure. However, increasing the number of aircraft families increased risk exposure less than other hedging methods. Indeed, airlines have been reducing fleet diversity, with European airlines seeing the greatest reductions. See also Treanor et al. (2014), Turner and Lim (2015), and Lim and Hong (2014). Finally, Rampini and Viswanathan (2010) and Rampini and Viswanathan (2013) examined the interaction between capital constraints and a firm's decisions regarding capital acquisition. Specifically, they studied the lease/buy decision and its interaction with hedging, which clearly has implications for aircraft purchases.

13.3 AIRLINE RISKS AND RISK MANAGEMENT

13.3.1 Capital Expenditures

As the global economy expands, airlines are expanding flights and routes. For instance, Clark (2017) reports that Ryanair will add 18 new routes in Italy in the summer of 2018. Meanwhile Hainan Airlines and Tianjin Airlines have filed applications with the Civil Aviation Administration of China for the right to fly new international services next year (Chong, 2017). Other examples abound. As these airlines expand, orders for new aircraft are surging. Kamihsni-Morrow (2017) reports that Emirates has signed a tentative agreement for 40 Boeing 787-10s, which will increase orders for this model to over 200. How do the airlines handle the huge capital costs associated with serving these new routes and passengers? It is rare that an airline will purchase new aircraft outright. Rather, they often lease the aircraft. Even if they purchase it, they may sell it to a leasing company and immediately lease it back. Leasing arrangements can be varied and complex. Russell (2017), for instance, reports that Aeromexico has secured financing for all new aircraft through 2019 using some cash and a variety of lease arrangements. These arrangements reduce the impact of the capital required, albeit at some cost to the airlines.

13.3.2 Fuel Cost Fluctuations

As noted earlier, airlines experience huge risks due to fluctuating fuel costs. Fig. 13.1 illustrates the rapid increase of crude oil prices leading up to the Great Recession, followed by a dramatic decline.[3] Prices increased from around \$20 per barrel to almost \$140, before falling to under \$40 in

[3] This and several other figures in this chapter are adapted from or reported by Sibdari, Mohammadian, and Pyke (2018).

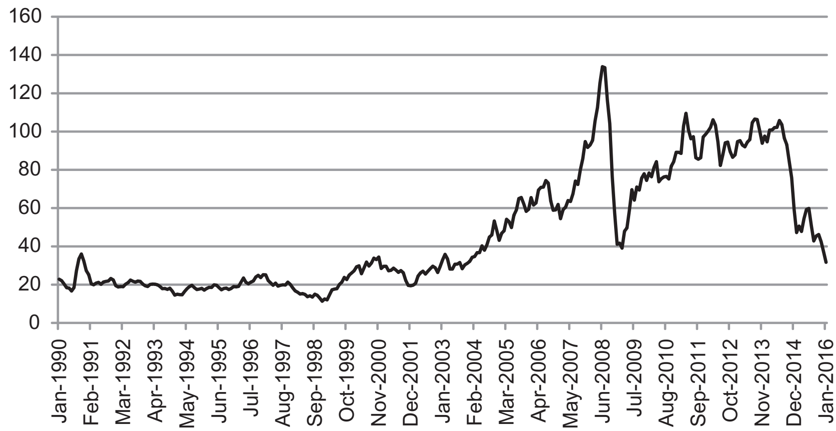

Figure 13.1 Crude oil prices between 1990 and 2015, Cushing, OK WTI Spot Price FOB (dollars per barrel). *Energy Information Administration (EIA).*

a short period of time. They since recovered to over $110, only to fall again to $30. At this writing, the spot price is just under $56 per barrel. Faced with such swings, the airlines have employed hedging to varying degrees. Fig. 13.2 shows the actual fuel cost per gallon (CPG) of several low-cost carriers and legacy airlines, which includes the hedged and market prices paid. As expected, airlines' fuel costs track the price of crude, but with some significant differences. For instance, Fig. 13.2 shows that Southwest had lower CPG than other airlines in the period before 2008, which is a result of their hedging policy. Southwest hedged about 70% of their fuel consumption in 2008 at a cost of $51 per barrel, while the market price was around $100. Such differences can lead to significantly higher profitability than their competitors. Many airlines thus followed Southwest's lead and began purchasing larger portions of their fuel through some form of hedging contract. The benefits were evident, especially during the rapid price increase prior to 2008. Unfortunately, the recession saw a collapse of fuel prices, and a number of airlines experienced huge losses due to hedging. Cathay Pacific in 2016, for instance, posted a net loss of $74.01 million, which analysts attributed in large part to bad fuel hedges. (Increased competition from Chinese airlines and decreased demand for premium cabin seats also contributed (Hong Kong's Cathay Pacific posts first annual loss since 2008, shares drop, 2017). Their contracts had locked in prices that turned out to be much higher than the market price. United lost $960 million in 2015 on poor

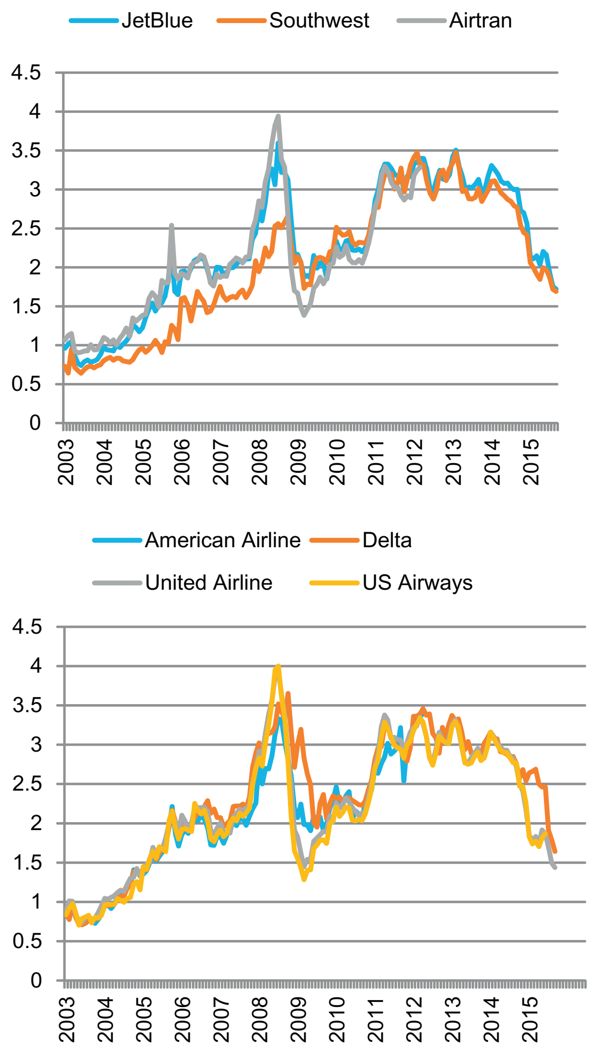

Figure 13.2 Average CPG paid by the carriers. *Research and Innovation Technology Administration (RITA)—Bureau of Transportation Statistics.*

hedging bets. A more stunning example is Delta, which lost about $4 billion due to hedging over the 8 years prior to 2016, with $2.3 billion in 2015 alone (Carey, 2016; Gosai, 2017).

Singapore Airlines (SIA) provides a more detailed example. As of February 2017, SIA extended some of its fuel-hedging contracts to as long as 5 years, clearly betting on an increase in crude oil prices

(Park, 2017). The carrier said it had contracted fuel hedges with longer maturities, extending to 2022 (SIA bets on oil prices going up as it extends fuel hedging, 2017). According to analysts, this was unusual for SIA as they usually employed maturities of 18 months. For the first quarter of 2017, SIA had hedged 37% of its fuel requirements at a weighted average cost of $67 per barrel. Longer-term contracts hedged 33%–39% of requirements at an average price of $53–59 per barrel. With all this activity, the airline lost S$365.9 million due to hedging in the three fiscal quarters through December 2016 (Park, 2017). Further detail can be seen in Table 13.1, which provides information about Air New Zealand's hedging contracts (Fuel hedge position as at 15 August 2017, 2017). As can be seen, the airline used several types of contracts to manage fuel cost risk, and they experienced losses through in the half of FY2018.

Anecdotal evidence suggests that some of the airlines' hedging departments had started to operate as separate financial services profit centers, rather than as a support to airline operations and cost management. The mixed results from hedging thus led most airlines to significantly reduce their use of these contracts. United, for instance, covered only 17% of 2016 fuel consumption with hedging, and American stopped hedging altogether in 2014 (Carey, 2016). Alaska Airlines, on the other hand, has followed a different approach to hedging, and it has proved successful. Rather than buying futures on crude, Alaska purchases insurance that triggers only if fuel costs increase above a negotiated cap. The insurance

Table 13.1 Sample of Air New Zealand's fuel hedge positions, FY2018 Q3

Sample instruments and periods	Barrels		
Brent Collars FY2018 Q3, Jan–Mar	1,360,000	Ceiling price—$53.20[a]	Floor price—$44.65
Brent Call Spreads[b] FY2018 Q3, Jan–Mar	75,000	Bought call—$53.13	Sold call—$58.00
Brent Swaps FY2018 Q3, Jan–Mar	262,500	Price—$49.14	
Bought Brent Puts[c]	125,000	Strike price—$40.00	

Total FY2018 H1 Jul–Dec 2017: Compensation from fuel hedges = $6,347,417. Purchase cost of options = $13,189,000. Net compensation = ($6,841,583). For the second half of FY2018, net compensation was $303,114. See Fuel hedge position as at 15 August 2017 (2017).

[a]All prices in USD.

[b]Brent Call Spreads lower the ceiling price of existing collar structures.

[c]Air New Zealand benefits if price falls below the strike price.

covers the additional cost over the cap. When other airlines were reducing or abandoning hedging in 2014, Alaska saved around $300 million by buying cheaper fuel (Gosai, 2017).

13.3.3 Currency Exchange Rates

Global airlines often earn revenues and pay for fuel, labor, and other costs in multiple currencies. As such, they are exposed to exchange rate fluctuations. This exposure can be beneficial to global companies. One global industrial company, for instance, pays most of its costs in pesos in its Mexican operation, while sales contracts for that plant specify that revenues are collected in dollars. When the peso weakened against the dollar, the profitability of the Mexican operation increased in a measurable way, even with no significant changes in unit sales or plant operations. A consumer product company, on the other hand, manufactures in the United States to support growing sales in China. When the dollar strengthened against the yuan, quarterly profit fell, in spite of improved performance on literally every other dimension.

Global airlines may experience similar effects from currency exchange rate fluctuations. Analysts suggest that, for the airlines, the impact of fuel cost variability dominates that of currency variability. Nevertheless, the effects can still be meaningful. In some cases, natural hedges can reduce the risk from exchange rate fluctuations. A natural hedge occurs for instance when cash outflows and inflows in different currencies balance out and thus reduce exposure. An airline can employ a natural hedge proactively by collecting revenues in the currency used to pay most costs. The economy can also provide a natural hedge, because costs tend to decline in a weak economy. Nevertheless, some airlines actively manage currency exposure by hedging. In 2009, Emirates employed hedging tools such as options, swaps, and natural hedges by paying expenses in Pound sterling, Japanese yen, Australian dollar, and euro. The airline reported that, for the year ending on March 31, 2009, net annual Australian dollar receipts were fully hedged, while hedging coverage for pound sterling, euro, New Zealand dollar, and yen were hedged 56%, 29%, 76%, and 38%, respectively.[4]

Airasia saw a decline in share price in August 2017 due to a large portion (90%) of its debt being denominated in the US dollars. The airline

[4] EK Group Annual Report, 2009.

had hedged two-thirds of its dollar debt at 3.23 ringgits per dollar, but the unhedged debt impacted its share price (Ren, 2017).

Lufthansa outlined its approach to currency hedging in some detail on its 2017 investor relations website. They reported that "international ticket sales and the purchase of fuel, aircraft, and spare parts give rise to foreign currency risks .... All subsidiaries report their planned currency exposure in around 65 foreign currencies to the central financial planning department over a time frame of at least 24 months. At Group level, a net position is aggregated for each currency in order that 'natural hedging' can be taken advantage of. Twenty of the planned currencies are hedged because their exposure is particularly relevant to the Lufthansa Group. The main currencies are the US dollar, Japanese yen, Swiss franc, Chinese renmimbi, and pound sterling. Currencies highly correlated with the US dollar are also set off against operating USD exposure" (Lufthansa Group: Investor relations: Hedging, 2017). This intense attention suggests that, even though fuel cost volatility is critical to the airline, currency risk is still significant.

13.3.4 Capacity and Revenue Management

As the airlines have ridden swings in the economy, fuel prices, and currency exchange rates, they made decisions about capacity on individual routes and across their networks. Capacity decisions for the airlines have widely different time frames. It can take years to take delivery of a new aircraft, while it only takes 3–6 months to reassign planes to different origin–destination routes (Cryderman, 2016). It is even possible to change planes within an aircraft family on a daily basis. This latter approach is called "re-fleeting," and it is feasible because flight crews are generally trained on multiple planes within the same family. However, because airlines pay a penalty for re-fleeting unless all ticketed passengers can be accommodated on the same time schedule, they do not appear to use this approach frequently. Another approach to increasing capacity is called "upgauging" (Carey & Nicas, 2015). One upgauging method is to add seats to existing aircraft. The Boeing 737-700, for instance, which has 137 seats, can accommodate up to 143 seats by decreasing legroom or by installing new seats. Some new seats are thinner and have smaller tray tables and seatback pockets, which minimize the effect on passenger comfort (Otis, 2013). In the current economic expansion, some airlines only buy the largest version within airplane family. Given a choice among the

737-700 (137 seats), 737-800 (175 seats), and the new 737 Max (200 seats), the larger versions appear to be the most frequent decision.

When the economy declines, airlines generally decrease capacity by delaying new orders (with associated penalties), mothballing part of the current fleet, or returning leased planes. They also reduce the number of flights to and from smaller airports and decrease the frequency of flights on a given origin–destination route. Cryderman (2016), for instance, reports that WestJet responded to falling oil prices by eliminating flights to and from Alberta. (One way carriers reduce flights is to eliminate the so-called shoulder flights, which are the first and last flights of the day.) El Gazzar (2015) noted in 2015 that Delta had increased capacity by up to 5% in the first quarter, only to reduce growth thereafter because of oversupply in the industry. American Airlines had likewise decided to cut seat capacity at the same time. Sasso and Schlangenstein (2015) reported that to reduce capacity on Japan routes, Delta planned to switch from 747s to smaller aircraft.

AirTran's reaction to the Great Recession and plummeting fuel prices was to scale back expansion plans. Prior to 2008, AirTran had positioned itself as a growing airline, and it had indeed maintained annual double-digit growth rates from 2000 to 2007. In 2008, however, AirTran implemented a reduction in fleet size, capacity levels, and capital expenditures (according to AirTran's Annual 10-K Forms). Even though AirTran had a capacity growth plan for that period, its capacity growth slowed to 4.9% in 2008, followed by another 2.2% reduction in 2009. One might assume that lower fuel prices in late 2008 would provide AirTran flexibility in capacity decisions. It could run excess capacity and lower load factors and make up the difference with reduced fuel costs. Apparently, however, the state of the economy outweighed the lower fuel costs, and AirTran decided to cut capacity.

Fig. 13.3 illustrates the aggregate flight frequency and average aircraft size for the US domestic market over the period from 2003 to 2015. In general, flight frequencies decreased over this period (by about 15%), while aircraft sizes increased by more than 25%, albeit with significant fluctuations. An overall measure of airline capacity is available seat miles (ASM), which counts the total available seats in one mile of a flight operation. Fig. 13.4 shows aggregate ASM for the US domestic market for the same time period. The Great Recession and subsequent recovery are clearly reflected in airline capacity decisions.

Two other factors are important to mention relative to capacity decisions. The first is competition, which introduces new constraints for the

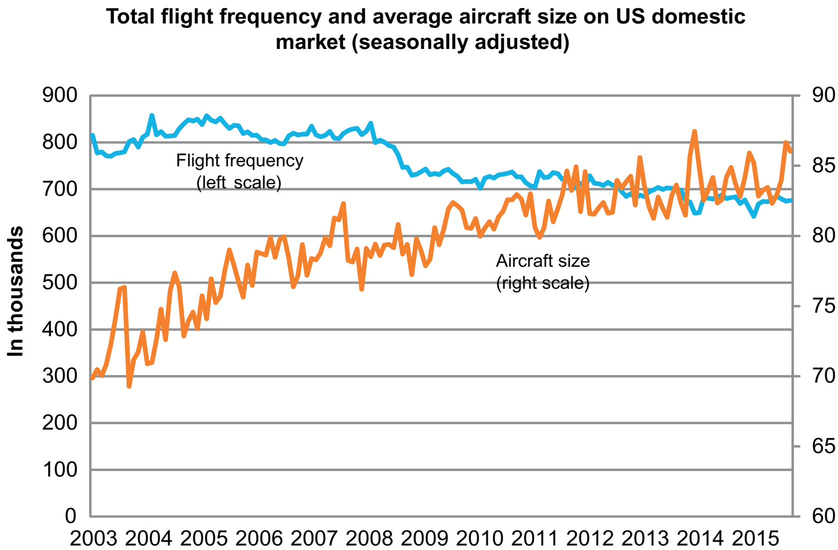

Figure 13.3 Total flight frequency and aircraft size for US Airlines on domestic market. *Research and Innovation Technology Administration (RITA)—Bureau of Transportation Statistics T-100 Market data.*

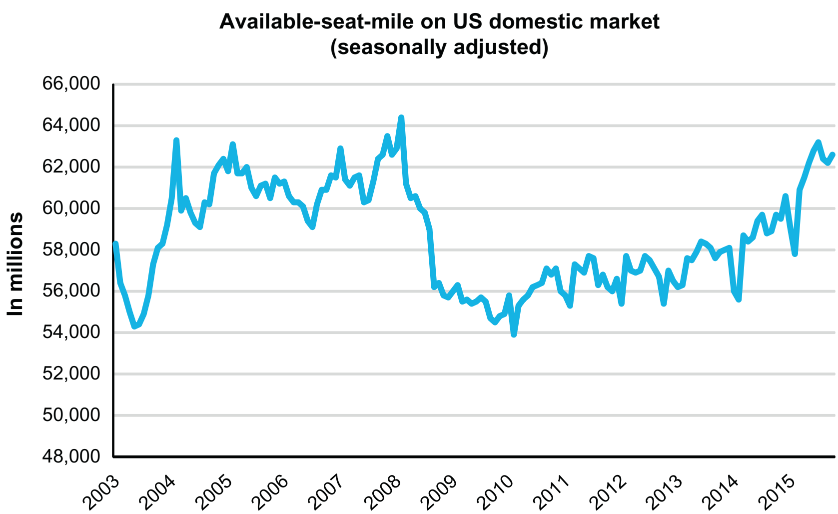

Figure 13.4 Air passengers and available-seat-mile in the domestic market for US Airlines. *Research and Innovation Technology Administration (RITA)—Bureau of Transportation Statistics T-100 Market data.*

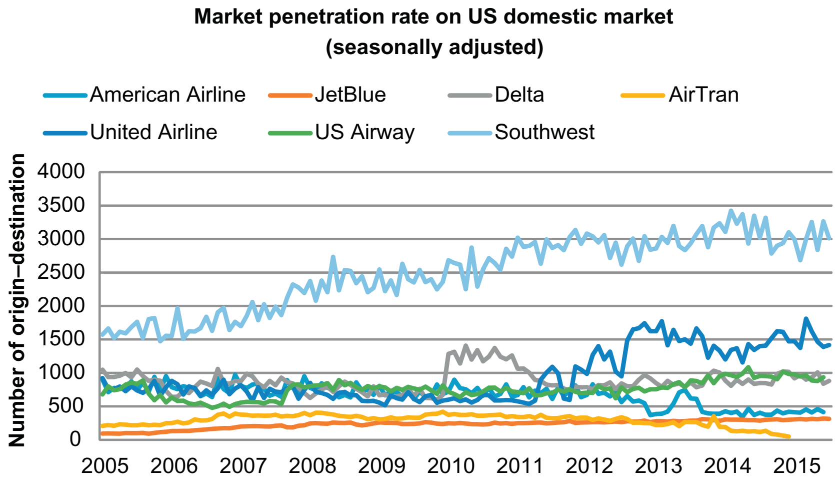

Figure 13.5 Market penetration rate by the carriers. *Research and Innovation Technology Administration (RITA)—Bureau of Transportation Statistics.*

airlines, especially as low-cost carriers enter new markets. Fig. 13.5 shows the shift of demand from US legacy carriers to US low-cost carriers. Indeed, our analysis of 13,164 domestic origin–destination flights during the Great Recession, reported by Sibdari et al. (2018), reveals that legacy airlines reduced their market size significantly, while low-cost carriers increased theirs. American, Delta, United, and US Airways' active domestic markets decreased by 12.7%, 23%, 18.3%, and 14.2%, respectively, while JetBlue and Southwest expanded into new markets at a rate of 12.4% and 11.4%, respectively.

The second additional factor relative to capacity decisions is revenue management. Revenue management tools are sophisticated mathematical algorithms based on the time remaining until a flight's departure date, the forecast of demand, and the number of open seats on the flight. They are designed to maximize expected revenue, which may involve overbooking and the occasional penalties associated with turning away confirmed passengers. Talluri and Van Ryzin (2004) provide an excellent and in-depth treatment of the algorithms and managerial issues associated with revenue management. Revenue management algorithms may change prices for a given seat multiple times before departure. Indeed, in some circumstances, prices can change hourly. Passengers may complain about such changes, but the fact is that passengers exhibit price elasticity, and revenue management systems ensure that the airlines benefit accordingly (Morlotti, Cattaneo, Malighetti, & Redondi, 2017).

One critical performance measure for the airlines, which is a result of both longer-term capacity decisions and short-term pricing decisions, is the load factor. The load factor is the ratio of passenger-miles traveled to seat-miles available, and as such is a measure of capacity utilization. Because revenue management algorithms take seat capacity as given, and because the marginal cost of adding a passenger to a plane is so small, revenue management generally seeks to increase load factors as high as possible. Fig. 13.6 shows that US airlines' domestic load factors steadily increased over 15% from 2003 to 2015, even through the recessionary period. Load factors averaged around 72% in 2003, and increased to about 85% in 2015, which explains in part why the airlines are finally profitable after years of poor financial performance.

One fascinating recent news item pertains to load factors. When fuel prices decreased dramatically from 2014 through 2015, many passengers wondered why airfares did not follow. If fuel is such a large component of airline costs, why would airfares remain high? Furthermore, why hadn't the airlines increased capacity as the economy rebounded from the Great Recession? Perhaps they were deliberately keeping capacity low in order to maintain high prices *and* high load factors. Indeed the US Department of Justice in 2015 opened an investigation into collusion by the airlines, questioning whether they unlawfully coordinated decisions

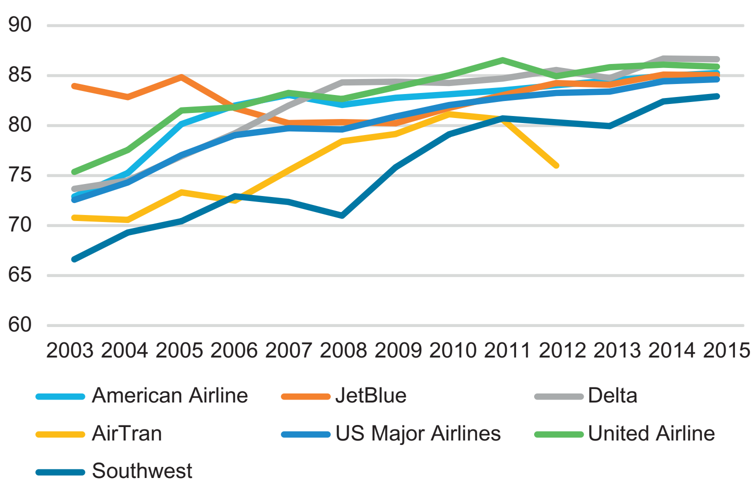

Figure 13.6 Load factors for US Airlines on domestic market. *Research and Innovation Technology Administration (RITA)—Bureau of Transportation Statistics.*

on capacity (Koenig, Mayerowitz, & Tucker, 2015). Against the government's case is the fact that investors had pressured the legacy carriers to hold steady on capacity, despite the economic rebound and lower fuel costs, to avoid the negative outcomes from overexpansion seen in previous cycles. Observers noted that the past few decades have seen periods of significant increase in total passenger demand, along with increased load factors, revenue per mile (RPM), and airfares. Yet, in some of these very time periods, most US carriers reported significant financial losses, and many of them declared or were threatened with bankruptcy. Indeed, there were nine significant mergers or acquisitions in the US airline industry since 2001, including American Airlines/TWA in 2001, US Airways/America West Airlines in 2005, Delta/Northwest in 2009, United Airlines/Continental in 2010, Southwest/AirTran in 2011, and American/US Airways Group in 2013 (see Gong, 2007; Merkert & Morrell, 2012).

It is clear that the airlines must manage huge risks arising from many sources. The evidence suggests that they manage these risks in silos, and that the results have been highly mixed, with some positive and some painful outcomes. In the next section, we summarize key results from an empirical study of their capacity decisions in response to volatility in the economy, fuel prices, and passenger demand.

13.4 THE IMPACT OF JET FUEL COST, PASSENGER DEMAND, AND UNEMPLOYMENT RATE ON AIRLINES' CAPACITY DECISIONS: AN EMPIRICAL STUDY

In this section, we summarize a subset of results from an extensive empirical study of capacity decisions for seven airlines operating on US domestic routes. Sibdari et al. (2018) studied three capacity decisions (flight frequency, aircraft size, and load factor) made in response to three exogenous factors (passenger demand, fuel cost, and unemployment rate). They considered seven US domestic carriers across 2003–15 and included both low-cost and legacy airlines: Southwest, JetBlue, AirTran, United, Delta, US Airways, and American. They aggregated the capacity variables by airline, by month, over the US domestic market. As is evident from the literature review in Section 13.2, fuel cost is rarely included as a factor in airline capacity decisions. Sibdari et al. (2018) incorporated actual fuel CPG, which allowed them to include market price paid and any hedging policies or fueling locations specific to each airline. Other data were gathered from publicly available datasets, including several from the Bureau of

Transportation Statistics (www.bts.gov), the Energy Information Administration (EIA, www.eia.gov), the Bureau of Labor Statistics, and air carrier financial reports and annual 10-K forms. They estimated average aircraft size by multiplying the number of passengers by the load factor and divided by flight frequency. Data were also adjusted by using seasonal indices.

A complicating factor in such a study is the possibility of endogeneity of the variables. As an example, is an increase in capacity the result of an increase in total airline passenger demand and the airlines attempt to capture this increase? Or is the increase in demand the result of an increase in capacity and the (possibly) associated lower prices? Hence, Sibdari et al. (2018) employed a two-stage least squares (2SLS) method, with which they estimated the total market demand in the first stage, and then in the second stage, they examined the effects of passenger demand, fuel cost, and unemployment rate on flight frequency, aircraft size, and load factor. Specifically, in the first stage, total market demand was estimated as an endogenous variable regressed against CPG and unemployment rate as exogenous variables, using RPM as an instrumental variable. The RPM instrument captured the impact of airfares in estimating total demand. Statistical tests verified the existence of demand endogeneity with respect to available capacity, as well as the validity of RPM as an instrument to effectively control for it. In the second stage, they estimated coefficients using the fuel cost, unemployment rate, and total demand estimated in the first stage. The general linear model was as follows:

$$\log(F_{it}) = \alpha_F + \alpha_1 \log(P_{it}) + \alpha_2 \log(Unemploy_t) + \alpha_3 \log(CPG_{it}) + \alpha_4 D_i + \varepsilon_{it1}$$

$$\log(ASize_{it}) = \delta_F + \delta_1 \log(P_{it}) + \delta_2 \log(Unemploy_t) + \delta_3 \log(CPG_{it}) + \delta_4 D_i + \varepsilon_{it2}$$

$$\log(LF_{it}) = \gamma_F + \gamma_1 \log(P_{it}) + \gamma_2 \log(Unemploy_t) + \gamma_3 \log(CPG_{it}) + \gamma_4 D_i + \varepsilon_{it3}$$

$$\log(ASM_{it}) = \beta_F + \beta_1 \log(P_{it}) + \beta_2 \log(Unemploy_t) + \beta_3 \log(CPG_{it}) + \beta_4 D_i + \varepsilon_{it4}$$

where

F_{it} is the total number of flights for carrier i in time period t.

$ASize_{it}$ is the average aircraft size of carrier i in time period t.
LF_{it} is the load factor for carrier i in time period t.
ASM_{it} is the available seat miles of carrier i in time period t.
P_{it} is the total passengers for carrier i in time period t.
CPG_{it} is the cost per gallon for carrier i in time period t.
$Unemploy_t$ is the unemployment rate in time period t.
D_i, $i = 1,\ldots, 6$, is the dummy variables, with Southwest as the reference carrier.

Here we report a subset of their results. In the first stage of the 2SLS model, for instance, they showed that as the unemployment rate increases, passenger demand decreases, which is intuitive. Likewise, as fuel costs increase, passenger demand decreases. This second result seems intuitive as well because airlines likely will increase prices, and consumers will have decreased purchasing power, due to higher fuel costs. It is possible, on the other hand, that fuel costs increase because of an economic expansion and the associated rise in demand for fuel. In this case, passenger demand might actually increase along with increased economic activity. The results by Sibdari et al. (2018) suggest that the inverse relationship holds.

The second stage of the 2SLS revealed several interesting insights. For instance, as the number of passengers increases, airlines respond with higher flight frequency. On the other hand, as fuel costs or unemployment rate increase, flight frequencies decrease. These results seem intuitive. The results for aircraft size are perhaps less intuitive, with an increase in passenger demand associated with a *decrease* in aircraft size. Carey and Nicas (2015), for instance, suggest that the opposite effect holds. Perhaps the reason for the model's result is that when passenger demand is high, the airlines expand service to smaller airports using smaller aircraft. Additional results indicate that aircraft sizes increase with fuel cost, which is consistent with economies of scale in aircraft size (Wei & Hansen, 2003). Thus, the data show that as fuel costs increase, airlines decrease flight frequency and increase aircraft size.

The model for load factor reveals that as fuel cost or unemployment rate increases, load factors increase. How is this possible? One explanation is that airlines employ pricing and revenue management to increase load factors, given the constraints of prior decisions on aircraft size and flight frequency. They seem to have been able to accomplish this in spite of the negative impact on passenger demand of an increase in fuel cost or unemployment rate.

The authors point out that their results both confirm and run counter to findings from prior literature. In particular, their results differ from Ito and Lee (2005) on the existence of a significant relationship between passenger demand and fuel cost, from Pitfield et al. (2010) on the relationship between passenger demand, flight frequency and aircraft size, and from Borenstein and Rose (2008) on the relationship between fuel costs and load factors.

13.5 AN INTEGRATED APPROACH TO AIRLINE RISK MANAGEMENT

All indications are that the airlines make decisions about capacity, hedging, and pricing in a decentralized, siloed approach. The empirical analysis in Section 13.4 raises the question of whether the airlines, or firms in other industries for that matter, could benefit from an integrated approach to risk management. As noted in Section 13.2, a number of papers have addressed some level of integration among various risks. None, however, have examined the decisions of hedging, capacity, and airfares in an integrated framework. Pyke, Shi, Sibdari, and Xiao (2017) address the question of the benefits that can accrue to an airline that integrates these three decisions.

Various modeling approaches have been used to incorporate the cost and benefit of risk reduction through hedging. One is simply an expected profit formulation, while others explicitly account for risk aversion via a conditional value at risk approach or a risk averse utility function. A common method in the literature is the mean−variance approach that assigns a "cost" to variability and takes the following form:

$$\text{Maximize [Expected profit} - (\lambda/2)(\text{Variance of profit})]$$

where λ is considered a measure of risk aversion.

Pyke et al. (2017) employ both an expected profit formulation and a mean−variance formulation. Their models are informed by previous empirical research, and in their stylized models, variability is introduced through uncertain demand and variable fuel prices. Fuel prices are random but follow a known probability distribution. Hedging reduces the uncertainty of fuel price, but comes at a cost to the airline—a cost that increases with the underlying variance of fuel prices. Thus, the realized fuel cost is composed of a fixed component at the hedged price, and a random component determined by the market price at the time the fuel is purchased for use. Demand is dependent on airfare and has a random component that follows a known probability distribution.

The authors employ a three-stage model in which the airline makes three decisions in sequence. First, the airline decides what percentage of fuel consumption to hedge for a given future time period. Second, given the hedging decision, the airline determines the number of seat miles to fly, i.e., capacity, and third, it sets the average price per seat mile. The authors propose to solve the problem backward in time by first determining the optimal airfare analytically for a given capacity and hedging percentage. Substituting this airfare into the capacity expression determines the optimal capacity, which in turn can be used to solve for the optimal percentage to hedge. At this writing, the analysis is ongoing, with a goal to understand how decisions at each stage change when integrated with the other two decisions. Ultimately, the goal is to provide insight into the value of integrated risk management in this industry.

13.6 CONCLUSIONS AND FUTURE RESEARCH

In this chapter, we have examined the risks that airlines face in a globally competitive and uncertain environment. We have outlined the ways that the airlines address these risks using the tools at their disposal, which include leasing contracts, currency hedging, fuel hedging, capacity decisions, and revenue management algorithms. We have also reported the results of an empirical study that helps understand how seven US airlines responded to the exogenous factors of fuel cost fluctuations, passenger demand, and unemployment rate, by adjusting flight frequency, aircraft size, and load factors. The results of that study suggest that as fuel costs increase, airlines decrease flight frequency and increase aircraft size. Likewise, as the number of passengers increases, airlines respond with increased flight frequency and decreased aircraft size. Furthermore, as fuel cost or unemployment rate increases, load factors increase. It seems that the airlines have increasingly been able to work within the constraints of earlier capacity decisions by adjusting prices to increase load factors.

Finally, we have outlined an analytical modeling framework for integrating decisions about hedging fuel costs, setting capacity, and establishing airfares. It is our hope that future research by a number of scholars will bring together empirical insights with analytical models to provide the airlines, and other industries, with a deeper understanding of the value of integrating risk management decisions.

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