

# Manage Speculation Risks in the Dry Bulk Industry

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## **Statement of Originality**

I, Luca Cocconcelli, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

## **Abstract**

The peak to trough phase in the dry bulk shipping market between 2005 and 2010 is the rational background of this thesis. The concomitant speculative events unfolding on commodity markets raise the question of whether or not dry bulk shipping market is exposed to speculation, if these speculative behaviours can be transmitted to the dry bulk industry from other connected markets (i.e. commodities) and if this speculation influences investment decisions of ship-owners and the sustainable growth of port cities.

Against this backdrop, this thesis represents a novelty and fosters the debate regarding the negative effects of speculation in the dry bulk industry. Additionally, it provides a comprehensive analysis of the key drivers of boom and bust cycles in the dry bulk industry and provides a conceptual framework to manage speculative risks. Given these objectives, first, this research demonstrates that the super cycle between 2005 and 2010 witnessed in the dry bulk industry was driven by speculative behaviours. Secondly, it proves that the dry bulk speculative cycle was related to recent speculative trends in commodities. Thirdly, the research shows how freight rates, commodity prices and port infrastructure influence each other and how speculation spreads to other important ship-owners' investment areas. Fourthly, it demonstrates that maritime speculation can be transmitted from port activities to the regional real estate market.

The findings emphasise that speculation modifies the investment decisions in the dry bulk shipping market. Additionally, the final results prove that dry bulk is affected by periods of boom and bust cycles leaving the entire industry prone to instability and excessive investment exuberance. Ultimately, the thesis contributes in the understanding of boom and bust periods to effectively manage speculative risks in the dry bulk industry.

## List of Publications and Conference Proceedings

The researches presented herein were enhanced by numerous suggestions and insights received by attending international conferences and by anonymous reviewers in peer review journal submissions. In particular, in order of appearance in the Thesis:

**Chapter 4:** paper published on *Journal of Decision Sciences, Risk and Management* - Special Issue on: ECONSHIP 2015 Current Challenges and Future Prospects for Shipping Markets and Ports with the title "*Testing speculative bubble in the dry bulk shipping market: a multi-factor approach*".

**Chapter 5:** conference proceeding at International Association of Maritime Economists (IAME) Conference, Marseille July 2013 with the title "*Parallel trends: a study of the relationship between wheat price and maritime freight rate*".

**Chapter 6:** paper presented at the Global Port Research Alliance Conference, Hong Kong May 2015 and under peer review on TransportMetrica A with the title "*Microeconomic determinants of dry bulk freight rates*".

**Chapter 7:** conference proceeding and paper presented at the Multinational Finance Society Conference, Prague July 2014 with the title "*A Framework for assessing speculative land value finance in port infrastructure development*".

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## Chapter 1 Introduction

### 1.1 Context

Speculation generates financial instability and undermines the sustainable development of national economies (Kindleberger, 2000). For long period of time, economic history regarded speculation as the trigger of boom and bust cycles (“speculative bubbles”) on capital markets and as a cause of financial distress and economic crises (Keynes, 1936). However, over the past 20 years, the world witnessed an unprecedented level of speculation: global capital markets have moved from one bubble to another and the bursting of one bubble has consistently led directly to the formation of the next (Shiller, 2015). This period has its roots in the Asian crisis of 1997 and the Russian/LTCM crisis a year later (Bernanke, 2006): fears of severe global financial and economic contagion led to very accommodative monetary policy, which fed a boom cycle in technology stocks and spread out into a bubble in a wider selection of stocks/indices, thus leading to the bursting point in 2000 (Kraay & Ventura, 2005). The response to the “dot-com” bubble’s collapse was again an ultra-loose monetary policy which led to an explosion in leverage and debt (Bianco, 2008). This period of high speculation culminated in the financial and housing boom and bust cycle of 2007-2010 (Phillips & Yu, 2011).

In the aftermath of the 2007-2010 financial markets meltdown, the combination of slow-to-negative economic growth and the weak recovery have increased attention on the main drivers of financials instability and their impacts on the sustainable functioning of global economies (Schularick & Taylor, 2009). A general accepted view attributes the responsibility of the latest financial crisis to speculative investments and boom and bust asset cycles (Crotty, 2009). The 2007-2010 crisis has brought up the necessity to detect

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financial instability and irrational exuberance such as explosive asset pricing dynamics, financial and economic instability in international capital markets (Shiller, 2012).

This is particularly true for the maritime industry and its dry bulk sector. The dry bulk sector plays an important role over the global movements of raw materials but is prone to boom and bust cycles, speculative investments and periods of irrational exuberance (Geman, 2005). As the main sector in the shipping industry, dry bulk carriers are large single hull vessels that engage with the transport of “dry” commodities and move enormous quantities of bulk raw materials across the globe (Stopford, 2007). The intrinsic characteristic of being the means by which the raw materials are shipped all over the globe leaves the industry prone to fluctuations, spikes and steep downturn associated to the behaviour of global economic activity and prices of the goods shipped (Hummels, 2001; Pettersen, 2012). As stated in Geman (2008), freight rates can be considered as part of the commodity market, particularly dynamic and fast changing with the technology endowments available. Nevertheless, dry bulk freight rates should be viewed as a cost of services, instead of a raw material devoted to the production of goods. In fact, shipping freight rates have the property of not being storable and they imply simple cost-of-carry valuations for futures contracts. Owing to this non-storable property, the freight rate spot market shows a high degree of volatility, which causes significant risks for ship-owners and charterers (Geman & William, 2012). These effects are dangerous for international trade stability: they leverage the peak to trough phases in maritime industry and provide fertile ground for speculation (in both freight rates and port investments).

Over the last century, the level of international trade has reached surprisingly high levels and, particularly over the past 30 years, trade flows have increased dramatically (UNCTAD, 2008). In a production world growing ever smaller, maritime industry has become the life blood of international trade and especially the bulk cargo segment is the main engine in the exchange of raw materials all over the world (Limao and Venables, 2001). It is clear that the industry is one of the key factors for local development,

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international trade growth and global wealth thus its efficiency and stability has a manifold impact on the distribution of the international wealth (Nijkamp, et al., 1990).

The dry bulk characteristic of being a cheap means of transport for raw materials has recently facilitated the integration of many Asian markets into the global economy thus leading to regional specialisation and ultimately higher levels of international trade (Lakshmanan, 2007). Raw materials and seaborne commodities account for, approximately, three quarters of international trade (Hummels, 2007), and, in the past 15 years, Asia has been the key player for commodity demand all over the world. Rapid and robust Far East Asia economic growth has been driven by China and has redefined the global patterns in merchandise trading and maritime transportation (Farooki & Kaplinsky, 2012). In particular, the strong Chinese economic growth has had a major impact on global commodity prices, demand for export goods and maritime freight rates: the sudden change in urbanisation trends and the Chinese production needs put pressure on commodity and dry bulk demand. The sudden shift in demand triggered a super cycle in commodity and dry bulk markets which had the pattern of speculative bubble (Liu, et al., 2013).

According to this background, speculation is a threat to the sustainable development of the maritime industry in three ways. First, it affects the normal level of freight rates (demand for cargoes). Secondly, it distorts the fleet characteristics (supply of services). And thirdly, it inflates the sustainable development of hard and soft infrastructures such as ports and port hinterland city growth. As a matter of fact, maritime industry is not only a mere commodity that ships raw material, semi manufactured goods and final products, but also plays a vital role in international trade and regional economic development; hence maritime industry sustainable development represents one of the most important topics in the international trade policy agenda (UNCTAD, 2014). Managing speculative risk in freight rates cycles remains a formidable challenge for both ship-owners and policy makers due to the vast array of factors influencing the demand for dry bulk cargo

(Stopford, 2007). Therefore, there is the need to provide a flexible toolset to effectively manage speculative risk in dry bulk industry, mitigate the negative impacts that speculation has on the sustainable growth of the industry and prevent periods of excessive investments which might lead to bankruptcies and market inefficiencies.

## 1.2 Objectives

Following the financial instability generated by the financial events (2007-2010), a large debate has sparked in order to prevent speculation. Economists, practitioners and researchers have actively engaged to tackle the negative outcomes of speculative behaviours (White, 2010; Gabor, 2015; Williams, 2015). In particular, among regulators (IMF, 2013) there have been a number of moves to limit the extent to which speculation affects the stability of major financial institutions (Financial Stability Board, 2014). However, this debate has largely taken place within the main regulated financial markets and institutions whereas large and important industries prone to speculative attacks have been left at the borders of this debate.

This is particularly true for the maritime industry and its dry bulk sector. The industry is prone to periods of boom and bust cycles while the core services are not exchanged in an organised market and are not subject to regulation (Stopford, 2007). Against this backdrop, this thesis represents a novelty and aims to generate a debate on the key risks of speculative behaviours in the maritime industry. In particular, this thesis tackles the risk of speculation in the dry bulk maritime industry with a particular focus on Far East Asia region, global financial dynamics and commodity prices. It provides a comprehensive analysis of the key drivers affecting boom and bust cycles in the dry bulk industry and it describes the multi-dimensional relationships with the key macro-economic, micro-economic and financial variables. The final goal is to deliver a flexible toolset which enhances the understanding of speculative risk in dry bulk industry, thus improving the management of freight rates boom and bust cycles.

Given these objectives, the thesis addresses the following four questions of research:

- 1) Did the dry bulk market witness speculative effects in recent years and to what extent did these effects influence levels of investment (**Chapter 4**)?
- 2) Did the speculative effects spill over to maritime industry from other financial markets (**Chapter 5**)?
- 3) Which are the main determinants that can influence the level of freight rates? Are there different vessel, commodity and structural factors that create over expectations in the market (**Chapter 6**)?
- 4) Does structural factor of maritime industry spill over to other connected market such as real estate property in port cities (**Chapter 7**)?

### 1.3 Structure of the Thesis

In order to achieve the goals listed in the previous section, the thesis structure follows an organic step forward analysis; first, it provides the quantitative rational background of the maritime boom and bust cycle; second, it proposes a theoretical framework to test, detect and manage speculative risks and finally back-test the main assumptions on real life case studies.

According to the visual reminder of this thesis depicted in Figure 1.1, the work is divided in four main-streams of research: the first phase is the “*Motivations and Objectives*” basket and provides the context, outlines motivations and specifies the objectives of this thesis (**Chapter 1**); the second phase is the “*Rational Background*” and presents evidence supporting the core analysis developed in the next sections. In particular, this part of the research investigates the rapid economic expansion in South East Asia (**Chapter 2**) and the boom and bust period in Commodity Markets (**Chapter 3**) over the past 15 years.

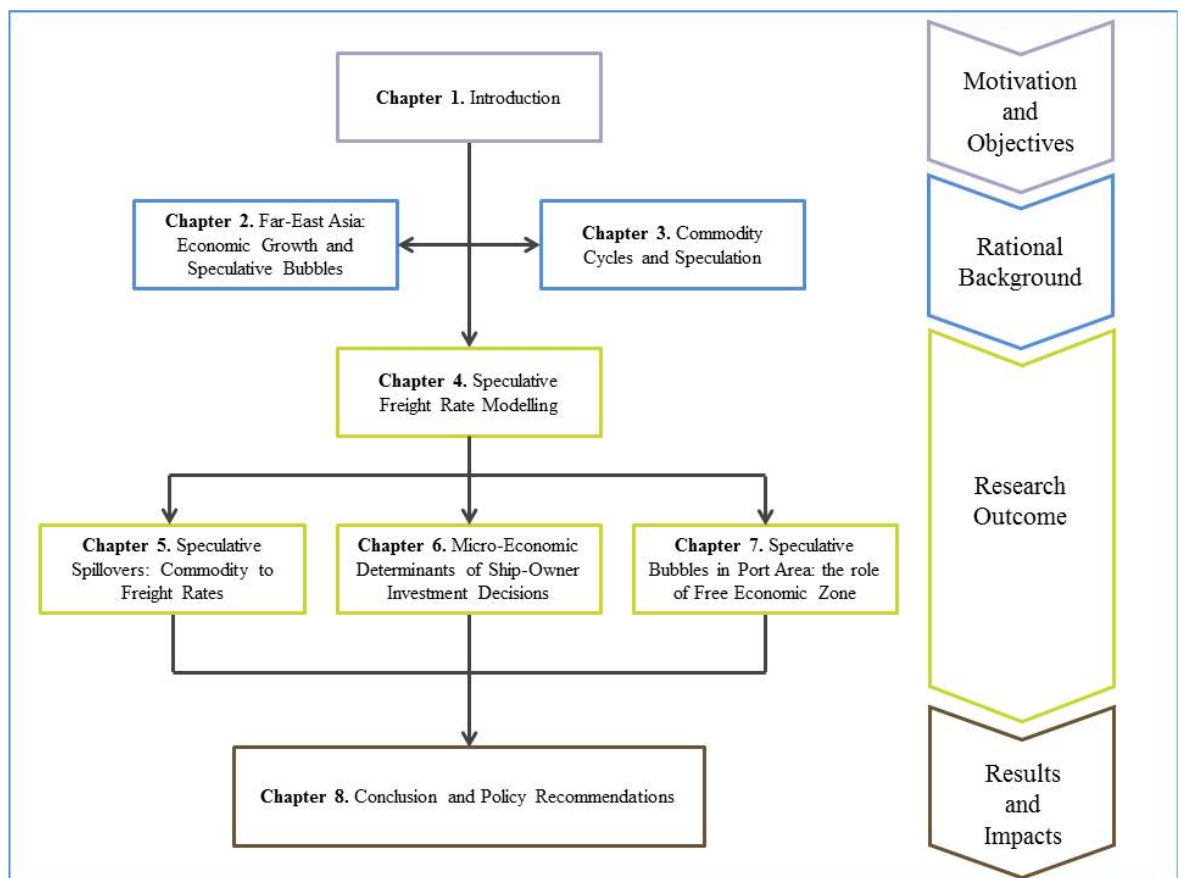
The third phase, the “*Research Outcome*” is the core part of the thesis and presents the main results obtained from the analytical analysis. This pivotal part of the thesis is structured as a step forward analysis which ultimately aims to describe the multidimensional patterns of the maritime industry: first, it assesses the presence of speculative behaviours in dry bulk freight rates by modelling the demand for new built cargoes (**Chapter 4**); second, the research evaluates whether external shocks from other



connected financial markets such as commodities can boost the boom and bust cycles in dry bulk freight rates (**Chapter 5**); third, it shows how freight rates, commodity prices and port infrastructure are influenced by each other and therefore how speculation not only spills over from commodity markets but can spread to other important ship-owners' investment areas (**Chapter 6**). Finally, it demonstrates how port investments are inherently linked to the context of regional development and therefore maritime speculation can be transmitted from port activities to the regional key economic variables (**Chapter 7**).

The fourth and final phase, the "Results and Impacts" section concludes the work by summarising the main findings, providing policy recommendations and critically discussing the main research results (**Chapter 8**).

**Figure 1.1** Structure of the Thesis



## 1.4 Research results

Managing the speculative risks in the dry bulk shipping industry is a complex research issue that involves the understanding of multi-dimensional effects and interdependencies between the variables under investigation. From the elementary relationship between business cycles and freight rates, surprisingly complicated theories and models have been developed to describe common phenomena such as investment cycles, regional economic dynamics and the international trade pattern. According to this background, the thesis shows how Far East Asian market liberalization and the financialization of commodity markets have affected the prices in both commodity and freight rates. The world financial markets developed a major boom and bust cycle in the aftermath of China Joining the WTO. Against this backdrop, this thesis provides the evidence that a speculative period was present in the dry bulk industry between 2007 and 2010. In particular, the thesis proves that a pivotal role in creating this cycle was played by market spillover from commodity markets. However, speculation in the dry bulk sector shouldn't be treated as a stand-alone financial effect and, as Chapter 6, shows speculation periods can influence the normal level of freight rates contracting and port investments. As Chapter 7 shows, speculation can be transmitted to the regional economy thus undermining the economic development of a region and the policies implemented to promote international trade.

The research results point to two important policy recommendations regarding political economy. First, speculative investments are non-trivial to detect and are often the result of micro economic and macro-economic friction between the main variables of global economy. Second, risk management policies should be enforced in order to prevent speculative behaviour. Periods of speculation in the dry bulk sector generates a short term unsustainable investment cycle in freight rate boom periods. The unsustainable level of investments leads to numerous bankruptcies when the freight market suddenly collapses.

However, in order to effectively manage speculative risk, the policies must be tailored and calibrated upon the context and the local social, economic and legal characteristics.

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## Chapter 2 Economic growth and speculative bubbles

### 2.1 Introduction

Economic and financial crisis are often the hard landing outcome of speculative cycles and asset price bubbles (Allen & Gale, 2000). A speculative bubble is a situation where asset prices are highly inflated and the value of assets is not correlated with the performance of their own fundamentals (Mishkin, 1996). Speculative effects are caused by sudden shifts in the macroeconomic environment, financial structure and social behaviours: often caused by investors' overconfidence and sustained by the money illusion phenomenon (Dusansky & Kalman, 1974), asset prices skyrocket and then suddenly revert into spectacular crashes (Akerlof & Shiller, 2009). In particular, the illusion of easy money and other behavioural biases, such as loss aversion, are the major forces inflating speculative bubbles: after the bust phase people tend to question why the asset collapsed by 50% but pay rather less attention to why the asset had run up to the peak so fast in the first place (Szyszka, 2013). As noted by Kent and Hirshleifer (2015), investors may overestimate future profits based on past returns: the belief that strong and safe returns will persist attracts an increasing amount of market participants, who often do not shy away from excessive leverage (Kent & Hirshleifer, 2015).

This is particularly true in the context of market liberalization: as discussed in Park (1996) the money illusion super cycle tends to happen more frequently and is often characterised by a sharp boom and bust phase in asset prices (Park, 1996). When market liberalizations occur, a sudden shift in supply and demand for assets distorts the investors risk appetite and generates an over-demand which ultimately results in a steep increase of asset prices (Stiglitz, 2000). As noted by Chandra (2015), when the capital markets are young and

inefficient, large volumes of Foreign Direct Investment flows towards the developing country that is undergoing the liberalizations; the sudden shift in the capital supply and asset demand put pressure on prices thus generating the money illusion. Some examples include the Russian crisis (Robinson, 1999), the Estonian crisis (Cocconcelli & Medda, 2013), Argentinian currency crisis (Cumby, 1989) and South Korean speculative cycle (Kim & Kim, 2003). Sustained by the money illusion, the large volume of capital inflows triggers the asset price super cycle that for a short period of time is able to feed for itself, thus returning generous profits to investors (Akerlof & Shiller, 2009). However, money illusion cycles don't last forever and investors find themselves trapped in a deflationary bust when the economic and financial wheels suddenly jam: the speculative house of cards crumbles leaving behind bankruptcies, economic crisis and unemployment (Taleb, 2010).

This is particularly true for the Far-East Region of the world which recently witnessed a large wave of reforms aiming to accelerate the transition towards an open market and free trade economy (Chirathivat, 2002). In the aftermath of the Chinese opening up to global trade (2001, Joining WTO), this region experienced a rapid growth in GDP, a sharp increase in asset prices (in particular Equities and Real Estate) and in Foreign Direct Investments. International liquidity, high GDP Growth and investors low risk appetite fostered a rapid expansion in asset prices. As Section 2.3 shows, the Far-East economic boom, lifted millions of people out of poverty, changed consumption habits and boosted the urbanisation process. These effects caused the Chinese demand for goods and basic materials to skyrocket between 2001 and 2009. The overheated macro-economic conditions developed into what many financial and economic analysts call the commodity super-cycle; the change in consumptions and investment behaviours triggered a peak to through phase in commodity markets that was claimed as the ultimate speculative bubble.

Against this background, Chapter 2 presents the main drivers of speculation, examines the recent market liberalisation and speculative cycle developed in the Far-East Asian

countries. Accordingly, the remainder of this Chapter is organised as follows: Section 2.2 presents the anatomy of a speculative bubble; Section 2.3 describes the recent economic trends witnessed by the major Far East Asian Countries, market liberalizations and the economic super cycle in commodity markets; Section 2.4 provides an insight on the main driving forces behind the commodity super cycle generated in Asia; Section 2.5 summarises the key aspects behind the far east boom and bust cycles and provide some critical remarks.

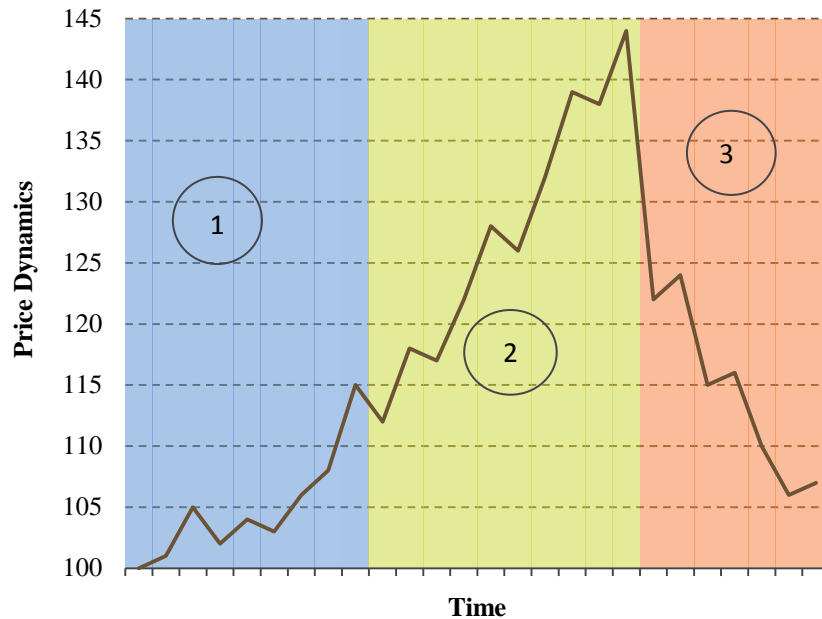
## **2.2. Boom and bust cycles in context: the case of rubber speculation**

A speculative bubble needs its own catalyst to kick off the asset price boom cycle: these events usually are caused by market liberalizations, credit expansions and irrational exuberance of investors which trigger investors risk appetite and increase the demand for risky assets (Phase 1 – Figure 2.1). In order to anticipate market movements and maximize their profits, during speculative periods investors increase their risk appetite, leverage their position and thus become more exposed to sudden changes and shocks (Hirshleifer , 1975).

The bubble in its developing phase biases the asset pricing, creates inflation and distorts the normal debt allocations of market participants hence boom and bust cycles are often related to opaque infrastructure financing schemes to sustain the debt level growth (Che & Sethi, 2014). A mechanism of self-fulfilling prophecies keeps the trend up-wards until it is possible to easily refinance debt position and access credit. According to Minsky (2015), the constant and rapid surge in asset prices instigates higher returns over the short-run, which in turn attracts a large number of new investors. The growing number of investors raises inflationary pressures which causes a strong increase in the general level of asset prices (Phase 2 – Figure 2.1). In the final phase the bubble bursts and asset prices collapse, often within a short period, a few days or months, and numerous firms and other agents, who have borrowed in order to buy assets, enter into default (Fisher, 1933). The bubble bursts when it becomes more difficult for borrowers to refinance their short-term

debt positions, thus creating a number of defaults and generating a spectacular crash in the price of the securities (Phase 3 – Figure 2.1). The numerous bankruptcies and defaults generate financial instability that propagates into a major contraction of the business cycles (Minsky, 2015).

**Figure 2.1** Speculative bubble development phases. Data are simulated.



As Allen and Carletti argue (2013), speculative bubbles have a multidimensional effect on financial stability and frequently lead to cascade effects that compromises different sector of the whole macro-economic system. In an open economy, debt positions of market participants tend to be fully integrated; therefore, the bankruptcies generated by speculative investment decisions affect the general functioning of the whole nation and ultimately corrupt the entire financial system.

An interesting case study is provided by the rubber boom and bust cycle which dates back to the dawn of the 20<sup>th</sup> century. At the beginning of the 1900, Brazil was the leading producer of natural rubber but a shortage in plantation supply couldn't match the fast rising demand of rubber across the globe. The natural shortage in rubber supply triggered a fast escalation in rubber prices and the rubber market peaked twice between 1906 and

1910. The sharp increase in rubber prices prompted a large wave of investments in order to gain profits from the remarkable price level: many western companies expanded their rubber plantations in particular in Far-East Asia and started to raise capital to finance their investments in Shanghai, which at the time was the dominant financial centre of the region. As the rubber prices continued to grow through 1910, the share prices of Shanghai-listed companies doubled as many investors were attracted by the persistently high returns.

Amid the rubber companies boom, the Chinese financial system played a vital role in sustaining the upward trend and inflating the self-fulfilling prophecies of rubber hyper-returns: in 1910, Chinese investors borrowed from local financial institutions (mainly via secured loans offered by pawnshops) in order to increase their exposure towards rubber stocks which, boosted by this financial leverage, outperformed any other asset traded on the Shanghai stock exchange.

However, due to the over-investment by Western companies, soon the new supply of rubber started to flood the global markets resulting in the sharp decline of the price of the commodity on the Shanghai Stock Exchange, starting in 1910. The market reversal generated panic among investors which triggered the rubber companies' stocks sell-off and prices sharply plunged. The collapse of rubber companies stocks led to significant losses among market participants who couldn't refinance their positions open with the pawnshops thus triggering a wave of bankruptcies across the local banking system. Ultimately, the rubber boom and bust cycle led to the meltdown of Chinese financial system, economic crisis and a deep social unrest that manifested in street riots.

The rubber speculation example highlights two key points and remains relevant to contemporary markets: first, unexpected market fundamental dislocations or short term shocks can create a self-fulfilling price spiral which enables boom and bust cycles. Second, a global boom and bust cycle ultimately leads to peak to trough phases, margin

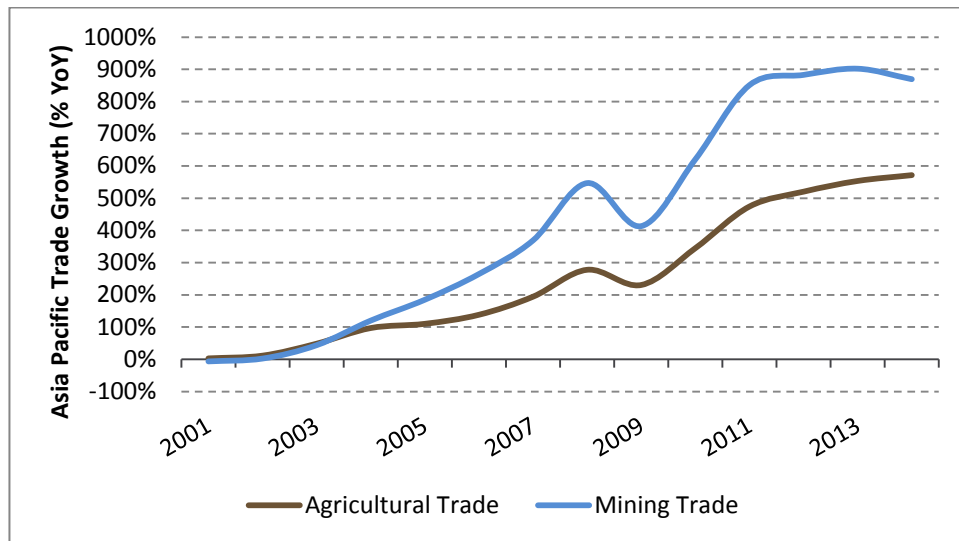


bets on future price dynamics, flawed investment cycles which bias asset pricing, leverage conditions and ultimately creates unproductive investments.

According to Minsky (1986), the level of debt is irrelevant as long as the valuation of assets grows at least as fast as debt level; however, in speculative periods it is the growth in asset prices that directs investment decisions towards unsafe and seldom unproductive allocations (Minsky, 1986). In speculative cycles, investment returns are strong and asset growth keeps the pace with debt build up. Matter changes when investment returns fall below the cost of liabilities: in these circumstances debt servicing becomes unsustainable and defaults happen (Roubini, 2011). Here comes the second point: the panic generated in the market is just a symptom deriving from an investment misallocation which emphasises how investment were flawed and sustained by a temporary mismatch between supply and demand. As John Mills wrote, “panics do not destroy capital; they merely reveal the extent to which it has been previously destroyed by its betrayal in hopelessly unproductive works” (Mills, 1867).

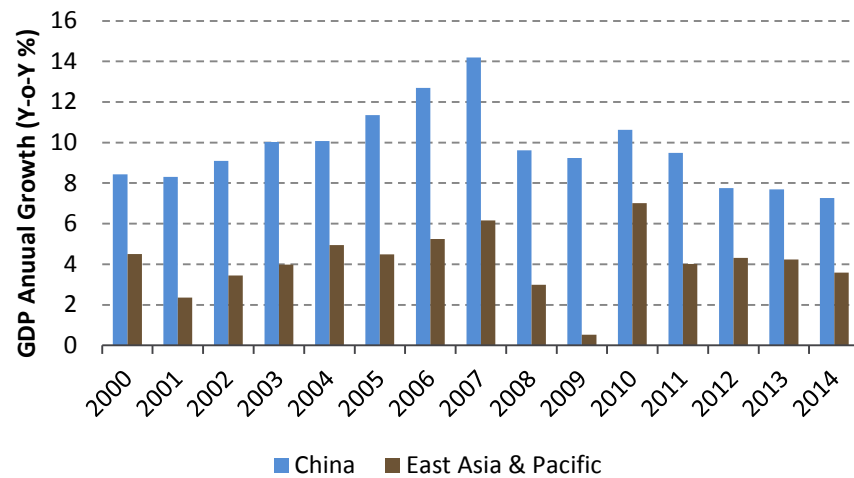
### **2.3 Speculative bubble: the Far-East dilemma**

One hundred year after the rubber speculative cycle, Far East Asia is again experiencing a marked increase in economic growth and asset prices as the main outcome of market liberalizations and a strong investment cycle. While the entire last three decades have been remarkable for the regional economic growth, two dates in particular signify the extraordinary changes taking place in the world economic landscape: December 11<sup>th</sup>, 2001 – which marks China’s accession to WTO, and November 30<sup>th</sup>, 2015 - when Renminbi was included in the Special Drawing Right basket of the International Monetary Fund currency, paving a way for it to become a global reserve currency.

**Figure 2.2** Asia Pacific trade growth (2001-2014). Data Source: Thompson Reuters database.

The first date is a milestone from a pure macro-economic perspective whereas the second shows the long-term view of the Chinese political establishment for transforming the country into a key player in the global financial markets. China has risen from the role of emerging country to become leading economic power, which after successfully completing an impressive economic transformation is now entering in a second phase aimed to become a global financial centre. In between these landmark events, there have been fifteen years of prolonged economic growth, expansion of merchandise trade activities and wealth generation (Figure 2.2). Since 2000 China experienced a fast and steady economic growth: the yearly average economic growth between 2000 and 2014 is an impressive 9% per year and it has outperformed all the emerging market peers (Figure 2.3).

**Figure 2.3** Gross Domestic Product: Year on Year (YoY - %) change for China and East Asia Region. Data Source: Thompson Reuters database.



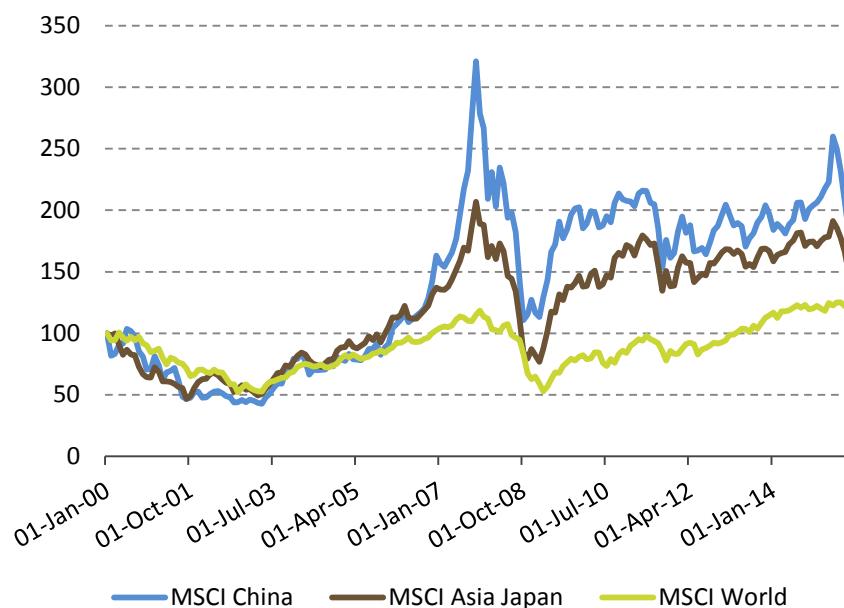
When China joined the WTO, it implemented a large number of reforms and market liberalisations which brought the world's most populous country to the forefront of reshaping the economic and political relationship all over the world. In particular, with a rapidly developing manufacturing industry, aggressive urbanisation and an extremely ambitious infrastructure plan, for the two decades, China was regarded as the forefront driver of economic growth and prosperity among the Emerging Market and Developed Countries all over the globe. Eventually, the strong and sustained Chinese growth has boosted the whole Far-East Asian region and has provided economic benefits for a wide range of countries geographically and/or politically close to China: Vietnam, South Korea, Australia, Japan, Hong Kong and Taiwan (Shambaugh, 2006).

The rapid economic growth has led to wider benefits in the entire East Asia region and has ultimately reshaped global dynamics in international trade, sphere of influence and the geography of production (Eckman, 2015). The Far East Asia economic growth led to general increase in the levels of international trade and boosted productivity (Dahlman & Sharma, 2012); eventually, the Chinese market opening has lifted millions people out of poverty within the country and between Far East Asian countries, it has driven a strong process of urbanisation and has increased the wealth level of Eastern Asian economies.

Finally, these events have increased the demand for commodity: hard (iron ore and copper in particular to supply house construction and production needs) and soft commodity (the largest share of world population lives in East Asia region) consumptions leaped in order to satisfy the needs of a fast growing region (Farooki & Kaplinsky, 2012).

The sharp economic growth of South East Asia has been followed by global investors closely and with particular attention: the main equity indexes for the region (namely MSCI China and MSCI Asia Pacific) have outperformed the global MSCI Benchmark for the entire decade from 2004 and rallied particularly strongly in the aftermath of the 2009 global economic crisis (Figure 2.4).

**Figure 2.4** MSCI Indexes: China, Asia Pacific and World. Data Source: Thompson Reuters database.



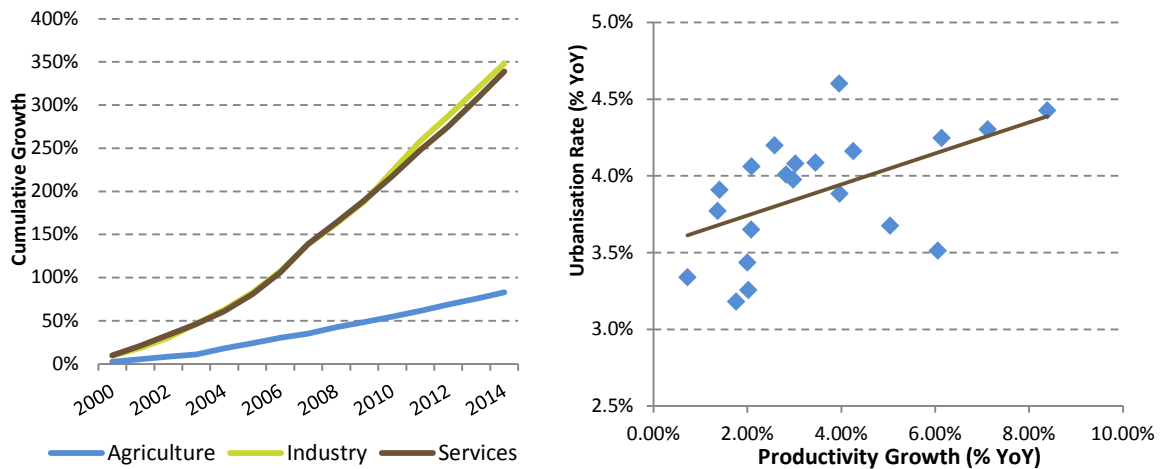
The Chinese boom triggered a wave of economic development to neighbouring countries and made the entire region a top destination for Foreign Direct Investments. The strong economic growth attracted a large volume of foreign direct investments from all over the world: BRICs and Emerging Markets became a very popular investment theme in 2000s and were one of the most profitable strategies for at least one decade (Ahmed & Zlate, 2014). Consequently, the massive increase in capital inflows have generated a strong

appreciation of all asset prices: as noted by Huang (2014), these speculative funds aim at short term profits and tend to distort the functioning of stock and housing markets. In a global environment of zero to negative interest rates, more investors poured liquidity into the fast growing Far East Asian markets: housing, stocks and commodity prices started a strong rally sustained by the large capital inflows (Choy, et al., 2013). Ballooning asset prices and easy money has led to money illusion: the super cycle generated boomed from 2001 and arguably, is still unfinished.

Super cycles are periods of high global growth and are driven by massive urbanisation rates, increase in population, technological improvements, increase in trade and high rates of investments (Brunnermeier, 2016). As Figure 2.5 (Part A) shows, from 2000 the two leading sectors of the global economy have been Industry and Services. The 10-year-average growth rate for industry was 10.54% and 10.38% in services while agricultural growth lagged at 4.11%. Indeed, for an emerging economy, to catch up, moving farmers to manufacturing plants is a key source of productivity gain in the early stage of an economic development. Fast urbanisation in the past three decades made up for China's relatively slow labour growth and accounted for about 30% of the impressive total factor productivity growth.

As Figure 4B shows there is a strong and positive relationship between urbanisation growth and productivity. It is worth noting that according to the United Nations, China's urbanisation rate is still very low compared to other economies at a similar development stage.

**Figure 2.5 (A and B)** Fig. A: cumulative Chinese economic growth by sector; Fig. B: urbanisation rate to productivity growth scatter plot. Data Source: Thompson Reuters database.



High urbanisation rates in developing regions of the world and rapid economic growth in the middle classes have particularly big impacts on commodity demand, both hard (iron ore and copper in particular to supply house construction and production needs) and soft commodity (the largest share of world population lives in East Asia region and the increase in purchasing power is often associated with an increase in consumptions of alimentary commodities) (Erten & Ocampo, 2013). The huge demand for commodity was substantially absorbed by major exporting countries (Australia, South America and North America for hard and soft commodities – Arab peninsula for Energy Commodities).

## 2.4 The Chinese hard landing on commodity cycle

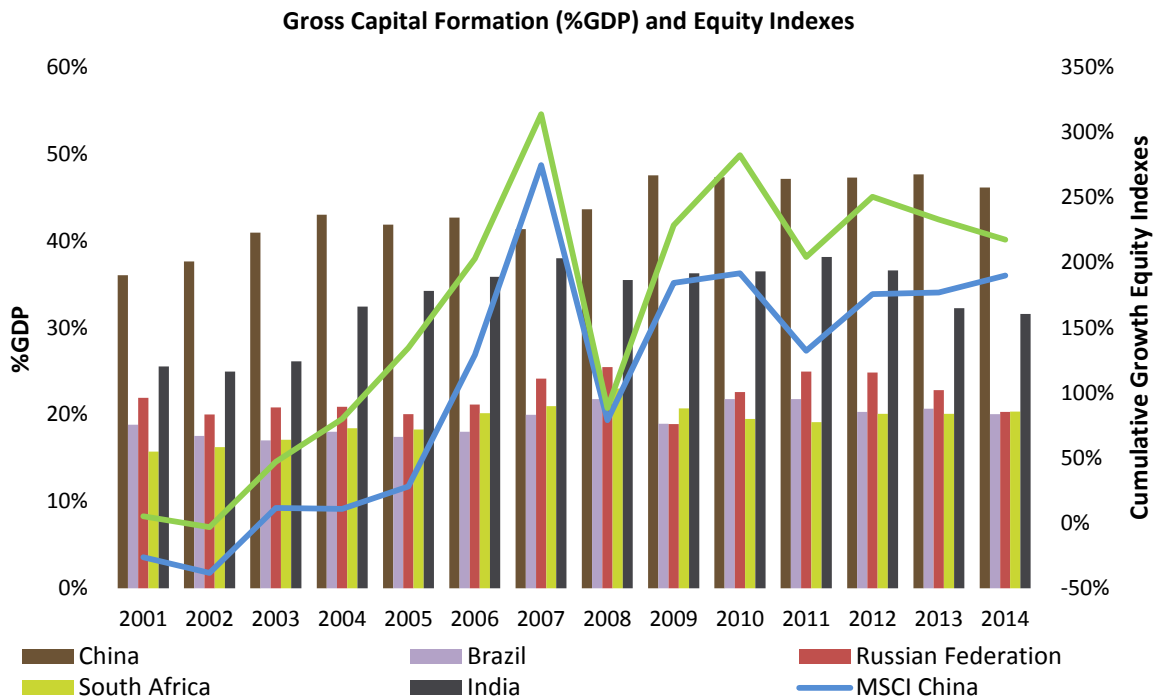
At this point, the question arises: how did we get from a fast economic growth into a speculative super cycle?

Money illusion and loose monetary policy are among the key global determinants. After the Asian/Russian/LTCM crises in late 1990s, the world has entered a new era of economic and financial super-cycles where accommodative monetary policy has been driving asset cycles from peak and then to trough (Borio, 2014). Cheap interest rates and easy access to credit have driven the increase in the overall/absolute debt levels globally.

Often these debt positions have been used to finance speculative investment: most visibly - the 2000 economic bubble, the subprime crisis, the euro solvency crisis (Gali', 2014).

It should be mentioned that the role played by debt depends on numerous factors. First, the level of debt is irrelevant as long as the valuation of assets grows at least as fast as debt (Fisher, 1930). When investment returns stay strong, assets keep pace with the debt level grow rate (Mishkin, 1996). The major problem arises when investment returns fall below the cost of liability thus making the service of debts unsuitable (Mises, 2006). In 2005, returns on investments in Far-East Emerging markets were high, debt level in these countries were low hence risk appetite suddenly shifted and investors increased the debt structure in order to profit from the rapid asset price growth. In this context, the Chinese economic growth played a pivotal role and was the epicentre of the impressive commodity super cycle that started in early 2002, soon after China joined the World Trade Organisation. As manufacturing shifted from Developed Countries to China and as China started to consume 40% of the annual global output of copper, iron ore, tin lead and zinc, many thought that a commodity boom was in place and finally the Malthusian trap theory finally was verified. So much that commodity producers hyped their investments and commodity countries double their deployments toward the expansion of capacity. The strong and sustained commodity boom drove funds and monetary flows into Emerging Countries. This trend was further strengthened by decreasing bond yields in most of developed markets while the globalisation of financial markets, pushed capital flows toward more attractive regions of the world as investors sought new markets to generate strong returns (Gourinchas, 2012).

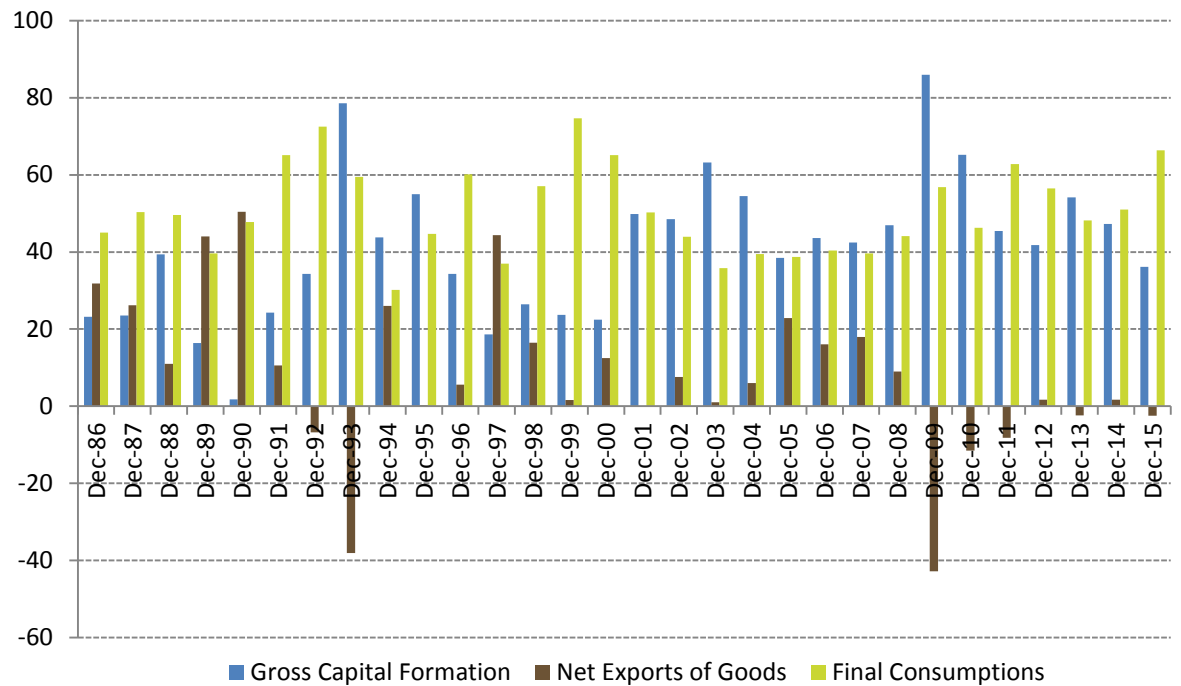
**Figure 2.6** Investment cycles in Emerging Countries. Data Source: Thompson Reuters database.



As a matter of fact, the large amount of liquidity directed toward China was deployed in particular towards investments and capital accumulation. As Figure 2.6 shows, the main contributor to Chinese GDP Growth has always been the gross capital formation that in 2009 reached extraordinary level and jumped to 86% of the overall economic growth. Another interesting pattern is the constant rise in Final Consumption contributions to Economic Growth: in 2015, Final Consumptions accounted for 56% of the overall economic growth while in 2003 this number was 35%.



**Figure 2.7** China, Sector Contribution to Real GDP Growth (%). Data Source: Thompson Reuters database.

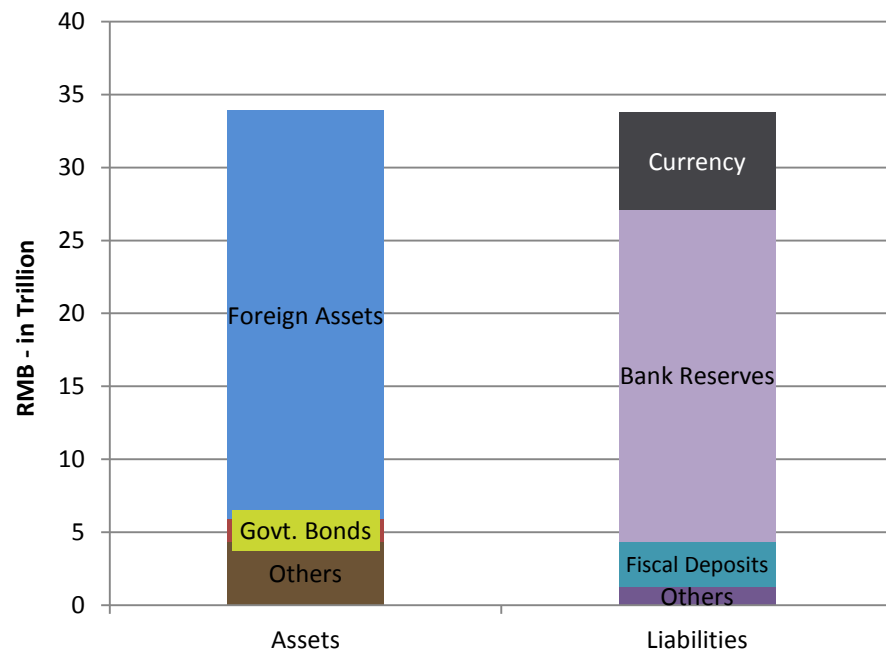


Benefiting from strong commodity and demographic trends, Emerging Countries established a supply boom aiming to integrate its growing workforce into the global production process while capital spending pushed productivity growth beyond labour compensation rates. Simultaneously, local households ran high saving ratios forcing Emerging Countries to generate current account surpluses. These surpluses were recycled – often via central bank reserve – back into developed markets sovereign bonds. This process had the effect of flattening the yield curve of the industrialised countries' government bonds, a phenomenon which would traditionally occur due to the weaker economic growth prospects was instead prompted by large capital inflows (Chen & Tsang, 2013). Taking advantage of lower funding costs, many western countries developed credit boom in turn pushing investors into more risky assets or into higher yield emerging markets assets (Trueck & Wellman, 2015). The subsequently rising Developed Markets risky asset evaluation allowed banks to use the valuation inflated assets as additional collateral, pushing more and more leveraged funds into the economy.

The capital inflows into Far-East Asia Emerging Economies eased monetary policy further and central banks failed to fully sterilize the additional FX pumped into local economies.

The strong economic growth and the constant increase of asset prices led to a massive capital inflow into China. This large capital inflow was reflected into the constant increase in Reserve Requirement Ratio (RRR) imposed by the People Bank of China (PBoC) on banks operating in the country. Since mid-2003, RRR increased from 6% to 28% in 2008 and as of 2015 it was at 19.5%. In particular, between June 2006 and June 2011, the PBoC was forced to adjust the RRR 35 times, bringing it from 7.5% to an all-time high of 21.5%. This constant change in RRR policy was mainly caused by the massive one way capital inflows into China during the year of global imbalances. At that time, the RRR served as a tool for large scale sterilization thus offsetting the rapid surge in domestic liquidity supply created by the capital inflows. Initially, China's exporters sold US dollars to commercial banks, which in turn moved the Dollars to the PBoC to receive RMB. As a result, RMB was issued by the central bank and flew into the real economy via commercial banks. To prevent supply from rising too fast, the PBoC then raised RRR for banks, essentially requiring banks to hand over a rising portion of deposits back into the PBoC. Only in this way, the PBoC could effectively reduce the money circulating in the real economy.

However, this monetary policy tool is weak and causes several undesirable outcomes. First, it means a rapid accumulation of FX reserves. As Figure 2.8 shows, the PBoC balance sheet, on the asset side, over 80% of China's central bank assets are foreign reserves, reflecting the cumulative foreign capital inflows into China. Correspondingly, on the liability side, the bulk of the PBoC liabilities are bank reserves locked up by an ever rising RRR.

**Figure 2.8** Asset and liabilities: People Bank of China 2015. Data Source: Morgan Stanley.

Second, the monetary policy becomes less effective. In the past decade, a large part of China's monetary policy focus was to drain the liquidity initially injected into the economy due to the PBoC's FX Purchases. High RRR is equal to a tax levied on banks: by holding US\$ as its assets and RMB as liabilities, the PBoC is in a negative carry with the return on its asset lower than that on its liabilities. Additionally, since exchange rate is largely fixed by PBoC, external shocks are then transmitted to the inter-bank market.

Hence, the world economy developed a super cycle where rising Developed Markets and Emerging Countries asset prices loosened financial and monetary conditions. Driven by an unprecedented low level of interest rates, looser financial conditions created a vicious circle of more liquidity which via East Asia's recycling fostered the increase in asset price level. The commodity market wasn't immune to the speculative super cycle: following the economic, social and financial trends developing in Far-East Asia, the commodity market underwent a peak to trough phase that drove the main commodity to a rapid surge and to an abrupt tumble between 2005 and 2015.

## 2.5 Conclusions

The rapid economic growth driven by Chinese liberalisation has lifted millions of people out of poverty, created jobs and boosted level of urbanisation. The sharp economic expansion has attracted a massive inflow of capital to Far East Asian countries. The high capital inflows have fed a speculative super cycle in housing, stock and in particular they had an important effect on the prices of commodities, both soft and hard. In fact, as shown in Section 2.4, the Far East Asian super cycle played a key role in driving the commodity market over the past decades; however, demand rising through population growth, increased wealth or urbanisation does not necessarily mean that all commodity prices rise in response. Historically, commodities have reacted differently through super-cycles. Factors have included prices controls, lack of investments, insufficient production and technological innovations. Additionally, the characteristics of specific commodities have always determined their supply, demand and their magnitude of their price paths during super-cycles. Indeed, there is a key difference between this and previous commodity super-cycle: it is called the financialization of commodity markets which have accelerated further the fluctuations in commodity prices. The unprecedented era of a low to negative interest rate in many developed countries has pressured the commodity prices and developing countries into a super cycle boom and bust cycle where excessive liquidity and investors' overconfidence have created a sort of monetary illusion with high and sustained returns and low risk. How this has happen will be the subject of Chapter 3.

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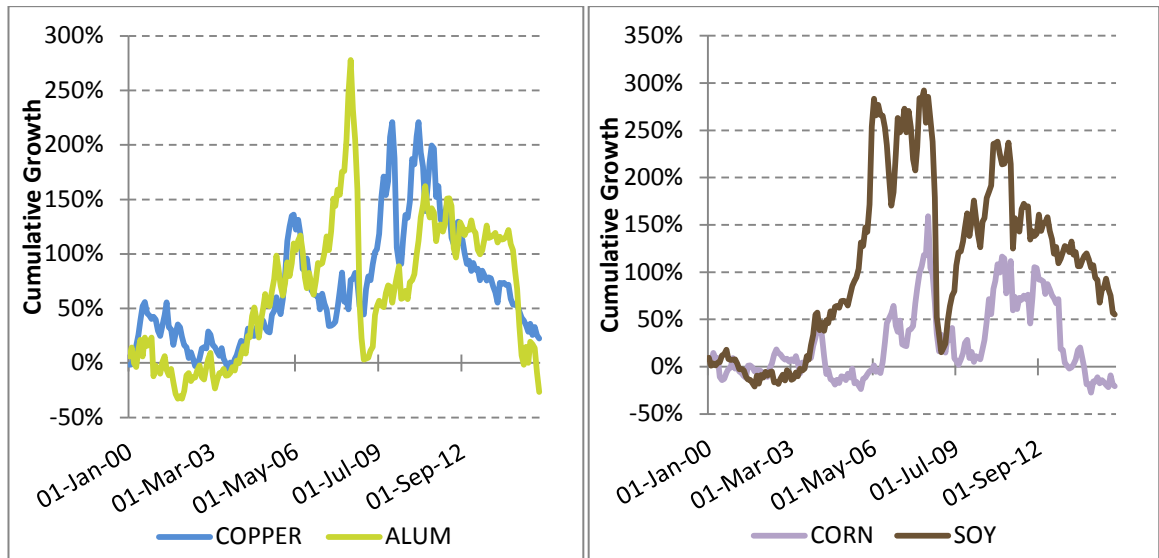
## Chapter 3 Commodities and freight rate

### 3.1 Introduction

Understanding the dynamics of storable commodity prices and how they relate to fundamentals of supply and demand remains a formidable challenge for policy-makers and economists. Episodes of sudden increases in price volatility, which are not necessarily aligned with detectable contemporaneous shocks in the underlying supply or demand, have perplexed economists in their quest to explain price dynamics, particularly in relation to the recent spikes in agricultural commodity markets (FAO, 2011). These events have put pressure on core inflation in mature economies, created social and political instability and raised concern about food security in developing countries (Cecchetti & Moessner, 2008; Yemtsov, 2008).

More recently the world has experienced a dramatic fluctuation in commodity prices: metal, energy and agricultural commodity prices rose sharply between 2005 and 2007 (FAO, 2009). But, from the second half of 2008, prices then collapsed receding significantly from their peak in late 2007. At the same time, aggregate stocks of major commodities also declined to minimal levels in 2007–2008 due to high global income growth, urbanisation dynamics and biofuel mandates. Additionally, the strong Far-East economic growth fuelled the demand for metal raw materials and boosted extraction all over the globe. Given the low level of stocks and the sudden shifts in demand for metal, prices were very sensitive to shocks (on both supply and demand side) such as the drought in Australia or greater demand for biofuels following the oil price spikes (Wright & Cafiero, 2011).

**Figure 3.1** Main commodity prices: the boom and bust phase. Data Source: Thompson Reuters database.



As depicted in Figure 3.1, the trajectory of metal and agricultural commodities shows moderate fluctuations and periods of steep price increase followed by dramatic falls. Nevertheless, the highest spike of the last three decades occurred between 2005 and 2008. The steady rise in world raw materials prices has been determined by a combination of cumulative effects of long-term trends, more recent supply and demand dynamics, and governmental responses that have exacerbated price volatility. For instance, one factor that has led to the surge in prices includes the increase in income in developing countries (particularly Brazil, Russia, India and China) (Wright, 2009). Other factors such as interest rates, exchange rates and increasing oil prices have also affected the price path of commodities.

On the other hand, Masters (2008) argues that the sharp increase in commodity prices was caused by large inflows of investment coming from hedge funds, investment banks and “*index speculators*”. The peak to trough price phases and the high levels of volatility in commodity markets during this period suggests the presence of a boom and bust cycle fuelled by the increasing quantity of liquidity and numerous investors entering the market (Belke, et al., 2008; Akerlof & Shiller, 2009). These events have impacted on the decisions for investment, crop renewal and harvests leading to a reduction in the supply of

raw materials and bulk commodities, and by doing so, affecting overall world food security.

It is widely recognised that returns, volatility, and co-movements of the second order moment of a variable can vary across time and influence the variability in linked markets (Buguk, et al., 2003); in particular, in commodity markets, this effect is well known as volatility spillovers effect; (Du, et al., 2011; Zhao & Goodwin, 2011). Since most of the international commodity trade is shipped by bulk carriers from point to point across the globe, understanding pricing dynamics on the commodity market is essential to further investigate dry bulk freight rate cycles. The aim of this Chapter is to shed a light on commodity markets behaviours, functioning and main changes of recent years, with a particular focus to the financialisation of commodity markets.

Against this background, Chapter 3 is organised as the following: Section 3.2 introduces commodity and price modelling; Section 3.3 describes the important role played by inventories in determining the spot and future prices of main storable commodities; Section 3.4 shows how inventories and financial contracts are related and how speculative behaviours interfere with the normal functioning of these mechanisms; Section 3.5 summarises the key points and introduces the rational background to analyse comprehensively the dry bulk industry and commodity prices.

### **3.2 Commodity price modelling**

Commodity price analysis, modelling and forecasting have long been a topic of interest for economists and researchers all over the world (Geman, 2009). This vast and multidimensional stream of research has led to different model specifications, statistical techniques and forecasting procedures in order to effectively account for several shocks influencing the availability of commodities and their relative prices (Ronconi, et al., 2015).

In general, commodities are natural goods and nonetheless consumption assets whose main characteristic is their scarcity (in terms of reserves or stocks) (Geman, 2005). Indeed, commodities share common characteristics with money: they can be held for everyday use, stored, or used as an asset. Indeed, one of the most basic divisions among commodities is between those which are storable and those who are not. This has a relevant implication on price fluctuations: as will be argued in the next sections, the possibility of holding inventories reduces drastically the price swings and volatility (Roache & Erbil, 2010). Among storable commodities, two main categories are present: the continuously produced and consumed and seasonally produced.

Among these categories, commodities are divided in three main baskets:

1. Metals or hard commodities
2. Energy
3. Agricultural or soft commodities

Metals commodity make up a large share of international trade and represent the fuel for the engine of the manufacturing sector. This group is formed by two sub-groups:

1. Non-Precious or Industrial Metals: iron ore, copper, aluminium, lead, zinc, tin, nickel, and cobalt;
2. Precious Metals: Gold, Platinum, Palladium, and Silver.

Industrial metals are used in all areas of industry and construction, from building houses and factories to the fabrication of electronics and consumer goods whereas precious metals also have value either as components of jewellery or as repositories of value in their own right.

Energy commodities include coal, liquefied natural gas, oil and electricity. The impact of the behaviour of these commodity prices is very important for consumer price indexes insofar as they affect extensively production costs of final goods. On the other hand, agricultural commodities are raw materials essential to dietary requirements of the world



population (grains, sugar, meat and fish) therefore these commodities are essential for the prosperity of the entire human being. Moreover, the increasing importance in the political agenda of reducing carbon emission put several governments in the position to stimulate the production of grains assigned to biofuels production (UNEP, 2009). The biofuel agenda has thus reshaped the production landscape in the agricultural commodity markets with some effects on the relative prices and supply/demand dynamics (International Energy Agency, 2012).

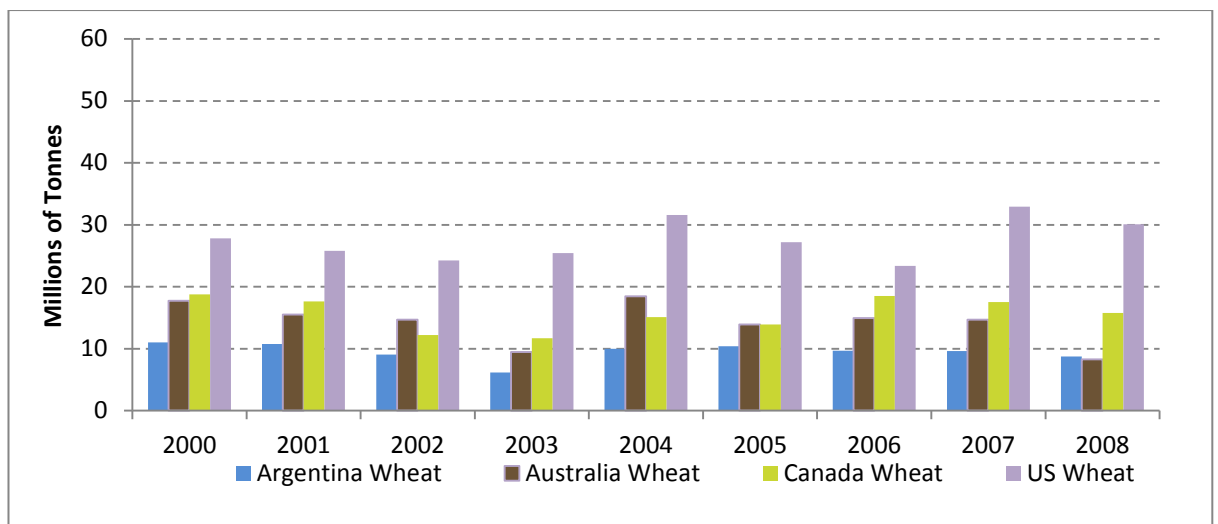
In the analysis of commodity price dynamics, it is noteworthy to describe the supply side, the demand side, inventory levels, perishability, and quality of the commodity under scrutiny: the interaction between these variables determines the spot price of a commodity traded on international markets. In fact, as Deaton and Laroque (1992) argue, commodity spot prices are a function of the scarcity relative to expected total demand. In storable commodities such as iron ore, copper, wheat, corn, and soybeans, the supply side is given by the current year production plus import from other countries minus export towards the rest of the world plus surplus stock left over from the previous year. Therefore, for any given storable commodity, carryover is defined as:

$$\text{Carryover} = \text{Stock} + \text{Production} - \text{Total Consumption} + \text{Import} - \text{Export}$$

Carryover is an important concept to estimate the whole availability or scarcity of a commodity in any given economy at any given time. It considers not only the production and the consumption of an agricultural commodity in a given year but also takes into account trade with foreign countries and the “savings” (stocks or stockpiles) gathered in previous years. As carryover is an insightful metric for commodity availability, it has a great impact on spot prices: if the demand for a commodity remains stable, a sudden drop in carryover is a symptom of a contraction on the supply side which is translated into an increase in spot prices.

To better understand the carryover concept I will focus on wheat characteristics in the US market, the major exporting country in the world. Coarse grains, the cereal commodity market and in particular the wheat market, are characterised by a limited number of major exporting regions (US, Canada, Argentina, and Australia accounting for about 83% of total exports, Figure 3.2). This characteristic makes the production very concentrated therefore the understanding of carryover changes becomes even more important. Table 3.1 summarises these peculiar elements in relation to US wheat availability for the forthcoming years and depicts fundamental aspects of the supply side of this commodity.

**Figure 3.2** World leader grain exporters. Data Source: FAO database.



**Table 3.1** U.S. Wheat supply and use. Data Source: USDA database – *WASDE Statistic Department*.

	2010/11	2011/12	2012/13	2012/13
			<i>Million Acres</i>	
Area Planted	53.6	54.4	55.9 *	56
Area Harvested	47.6	45.7	49.2 *	48.8
			<i>Bushels</i>	
Yield per Harvested Acre	46.3	43.7	45.4 *	45.6
			<i>Million Bushels</i>	
Beginning Stocks	976	862	728	743
Production	2,207	1,999	2,234	2,224
Imports	97	115	120	120
Supply, Total	3,279	2,977	3,082	3,087
Domestic, Total	1,128	1,186	1,238	1,223
Exports	1,289	1,048	1,150	1,200
Use, Total	2,417	2,234	2,388	2,423
Ending Stocks	862	743	694	664
CCC Inventory	0	0		
Free Stocks	862	743		

The first rows of Table 3.1 account for the total area planted, the yield (which is a measure of the productivity of an acre of land cultivated with wheat) and the total area harvested. This is roughly a mirror of the total production in a year. The other rows show other important factors in determining the carryover such as stock quantities (at the beginning and at the end of the year), number of imports (which contributes to increasing the supply availability in the country) and exports (the quantities of wheat sold to foreign countries, which reduces the supply quantity in the country). The main assumption of the price system in commodities is that when it becomes scarce, the carry over drops and spot prices rise, thus inducing a fall in consumption and signalling more investment in the production of that commodity (Grossman, 1975).

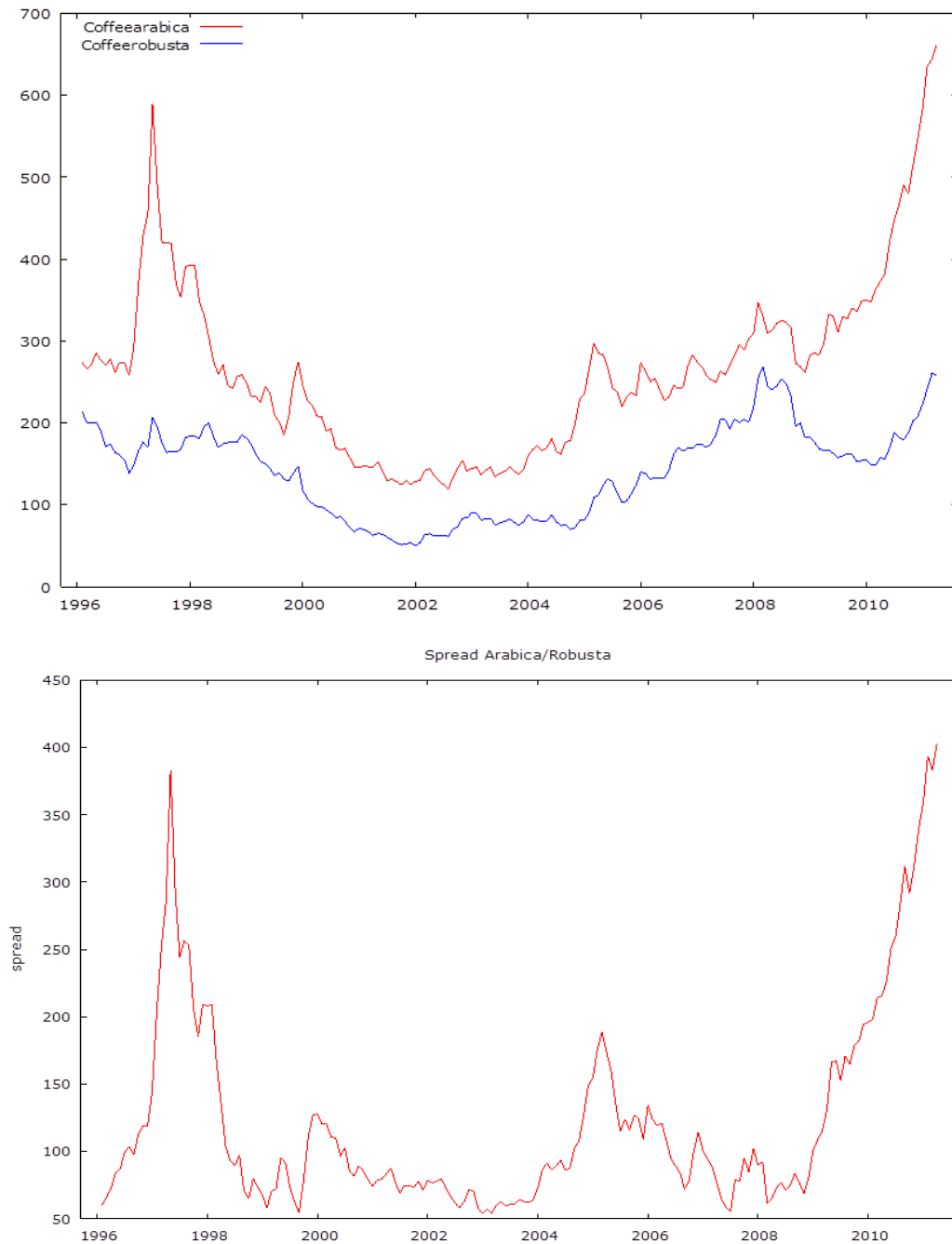
A good empirical example of scarcity and price level is given by another well-known storable commodity, namely coffee, of which two main varieties are cultivated: coffee *Canephora* (predominantly a form known as 'Robusta') and coffee *Arabica* (Otero & Milas,

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2001). Robusta coffee is originally from central and western sub-Saharan Africa, but nowadays is mostly grown in Vietnam, Africa and Brazil. Approximately 20% of the coffee produced in the world is Robusta (FAO, 2015). Coffee Arabica is originally from the mountains of Yemen in the Arabian Peninsula, hence its name, and also from the southwestern highlands of Ethiopia and south-eastern Sudan and is the first coffee variety cultivated over 1000 years ago (Smith, 1985). Robusta is easier to care for and to grow and has a greater crop yield than Arabica and thus is cheaper to produce. On the other hand, Arabica coffee is considered to be of superior quality thus trading at higher prices on the international coffee markets (Ghoshray, 2009).

Figure 3.3 depicts the time series of the two varieties of coffee beans and the spread between them, calculated as price of Arabica quality minus price of Robusta quality.

**Figure 3.3 A and B** Arabica and Robusta prices (Part A) and spread (Part B). Data Source: FAO Pink database.

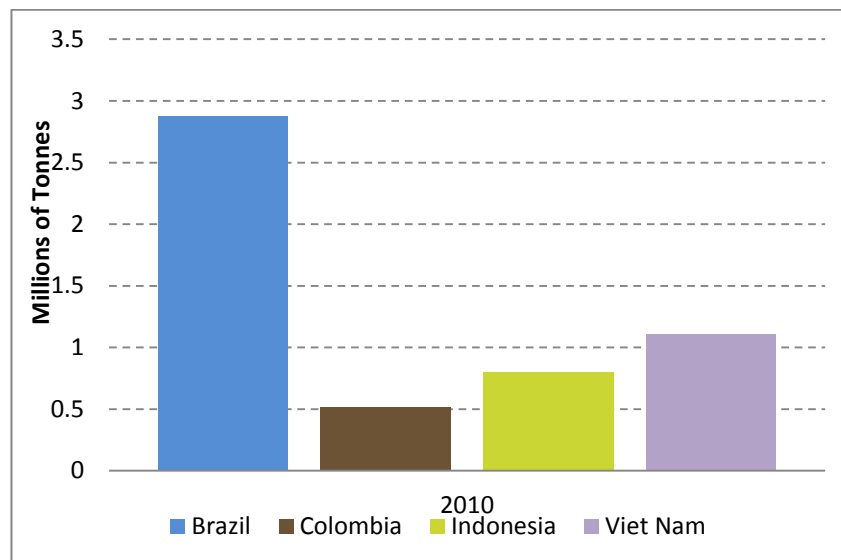


The two graphs help to understand how the lower quality and higher yields of Robusta influence the prices: the Arabica quality always has a price above the level of Robusta beans and sometimes has spikes due to external shocks. It is not in the purposes of this Section to discuss the causes of those shocks, but it is interesting to observe the right-hand side of Figure 3.3: it depicts the spread between Arabica and Robusta and shows a

very interesting cyclicity in the behaviour of Arabica beans prices. Why does this happen?

Brazil, the world leader in production of green coffee, produces about 40% of the world's coffee supply, followed by Vietnam, Indonesia and Colombia (Figure 3.4). Arabica coffee beans are cultivated in Latin America, eastern Africa, Arabia, or Asia. Robusta coffee beans are grown in western and central Africa, throughout south-east Asia, and to some extent in Brazil. Varietals are generally known by the region in which they are grown such as Colombian, Java and Kona.

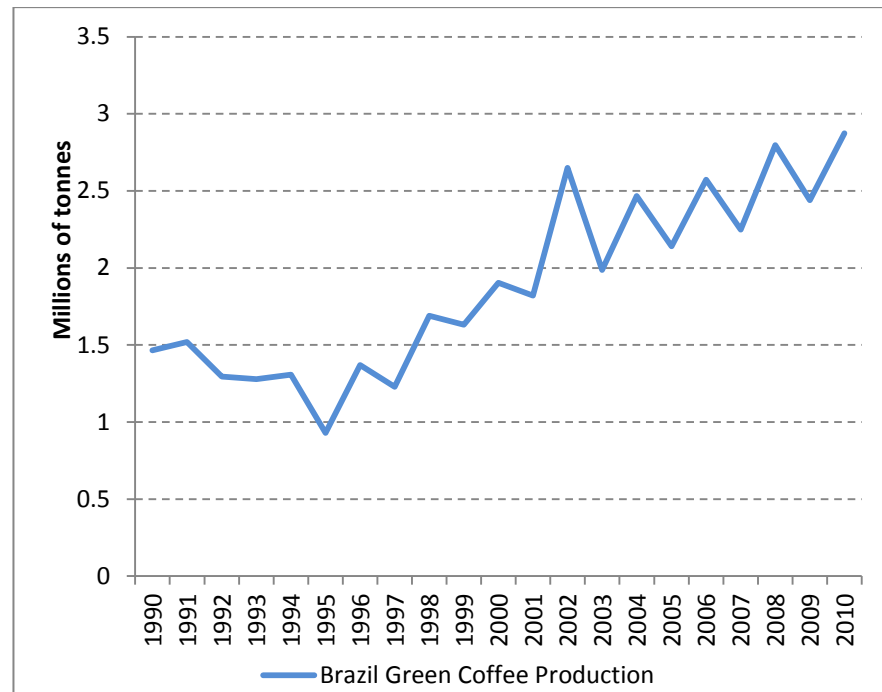
**Figure 3.4** World's largest coffee producers. Data Source: FAO database.



Brazil produces the higher quality Arabica beans which are used for the futures contract in the ICE (Intercontinental Exchange in New York): the size of Brazilian coffee crop can have an even larger impact on the longer term price direction of New York coffee futures. The Crop conditions, yields of harvested area and the sizes of future harvests can be forecast in advance, enabling a continuous backup of expectations about future conditions of supply side. Indeed, coffee plants in Brazil are characterised by an "up/down" yield cycle, which means that a larger harvest is followed by a lower harvest the next year, and

so on (see Figure 3.5). This effect can be mitigated by stocking the commodity when the harvest is higher and releasing the inventories when production is lower.

**Figure 3.5** Brazil green coffee production. Data Source: FAO database.



As stated before, in commodity markets the fundamental conditions of the supply are very important and the supply/demand relationship drives the market spot price formation. Hence, commodity inventories absorb future supply shocks and prevent large price fluctuations in the market thus curtailing commodity market risks (Gilbert, 2006). Additionally, inventories affect the level of carry-over only in the spot price formation but have great implications for the future prices at time  $t+T$ : in periods of risk and uncertainty regarding future harvesting or extraction due to a low level of carry-over, risk premium on future contracts increases and holding the physical commodity is profitable (Ronconi, et al., 2015). This effect pushes the demand for the spot physical commodity upward and contracts the future price. According to this mechanism, inventories bridge the spot price of a commodity to its future price and they play a major role in pricing commodity derivative in financial markets.

### 3.3 Commodities, reserves and scarcity

Inventories are important for commodity pricing since they influence present and future availability or the scarcity of goods (Roache & Erbil, 2010). In a competitive and volatile commodity market, producers, consumers and other parties have the incentive to hold physical inventories (Declerk, 2015). These inventories have different functions: they may be used to absorb shocks to production or to avoid stock shortages. In fact, storage is an asymmetric activity: an over-supply caused by an abundant harvest can be stored and consumed in forthcoming years while the stored reserves can be used to cushion future price spikes due to a shortfall in harvest.

Additionally, the role of inventories assumes important features in a world of financialised commodity markets where derivative contracts are used to offset risk, explore future price dynamics and base investment decisions (Yang, et al., 2001). Inventories link current and future supply of a commodity: they connect the spot to future expected prices, thus understanding their impact on pricing dynamics is a key element to mitigate risk on commodity markets. One of the first and most important contributions in understanding the link between commodity spot and future prices was given by Gustafson (1958), who studied the relationship between storage and price risk: he presented a model of the market for a storable commodity subject to random supply disturbances, thereby anticipating the concept of rational expectations developed by Muth (Gustafson, 1958; Muth, 1961). Muth was later able to show that competitive inter-temporal storage arbitrage can smooth the effects of temporary oversupply and, when stocks are available, temporary shortages.

According to Muth's (1961) view, inventories influence the present and future availability or scarcity of a good therefore strongly determine the price of a commodity: the buyer who needs a commodity at future time- $t$  can decide whether to buy it now (on the spot) and hold it (storage) or buy a future contract with delivery time- $t$ . In this activity, there are two main costs borne by investors who purchase on the spot market: storage costs and



opportunity costs. This view is emphasised by the storage costs theory (Kaldor, 1939; Working, 1948; Brennan, 1958; Telser, 1958) which explains the difference between spot prices and future prices in terms of costs borne for storing, warehousing and convenience yield on inventories. Storage theory focuses on three points:

- Storage costs;
- Why there are stockholdings on the physical market;
- The role of future market for price discovering.

The theory of storage emphasises the role of inventories as a buffer to sudden market condition changes and seeks to address the problem of non-convergence between spot and future prices (Spot-Future price spread). From storage activity another important concept of commodity economics emerges: the convenience yield. Convenience yield is the owners utility deriving from holding a commodity. This can be viewed as protection against a sudden drop on the supply side (Working, 1949). The assumption of this theory is that holding inventories gives a stream of benefits to the holders known as convenience yield (Brennan, 1958). Empirical evidence for this concept lay in the fact that spot prices are often above the level of future prices, implying a positive convenience yield, the remuneration to the risk and costs borne by the holders of a physical commodity for storage.

Accordingly, the marginal convenience yield is defined as the utility or gain derived from holding an extra unit of a storable commodity (Milonas & Henker, 2001). Inventories enable the owner to make profit from temporary price increases due to disruptions or shortages in the commodities production process (Mellios, et al., 2016). Therefore, convenience yield inversely depends on the level of inventories: if inventories are high, the marginal convenience yield is low; whereas in low level periods of inventories, the marginal convenience yield is high. Brennan (1958) argues that convenience yield can be viewed as an embedded timing option attached to the commodity: when prices are low, hold in storage; whereas when prices become high, release the inventories onto the

market. One of the main contributions in understanding commodity price behaviours is given by Gustafson (1958) who studied the relationship between storage and price risk, presenting a model of the market for a storable commodity subject to random supply disturbances, anticipating the concept of rational expectations developed by Muth (1961). He showed that storage is a competitive inter-temporal arbitrage that can smooth the price effects of temporary oversupply and, when stocks are available, temporary shortages. There is a well-documented negative correlation between stocks and level of commodity prices: high levels of inventories usually correspond to low commodity prices.

Now that the main components linking future and spot prices have been investigated, it is possible to mathematically decompose the spread between spot and future commodity prices. According to Geman (2009), the future price for a storable commodity is equal to the sum of the spot price plus storage cost plus the interests and minus the convenience yield (Equation 3.1).

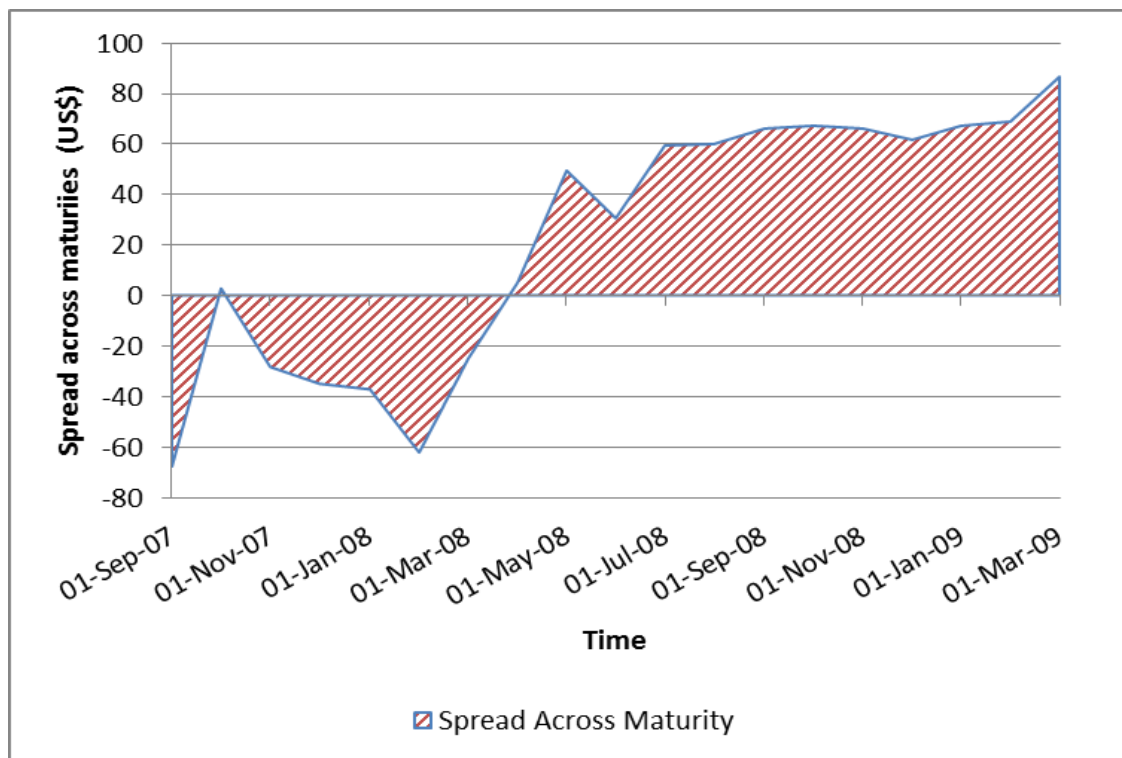
$$F_{T,t} = S_t e^{(i+c-y)(T-t)} \quad (3.1)$$

Where  $F_{T,t}$  is the future price at time  $t$ , which maturity is a time  $T$ ;  $S_t$  is the spot price of the commodity at time  $t$ ; and  $i$  is the interest rate,  $c$  is the storage costs,  $y$  is the convenience yields (Yang, et al., 2001). This relationship explains why there should not be risk free arbitrage gain possibilities:

- If the future price of a storable commodity exceeds the sum of the spot price and the cost of carry then there should be an incentive to buy spot and sell a future contract;
- Conversely, if the future price of any given storable commodity is lower than the sum of spot price and cost of carry there is an incentive to sell the commodity on the spot market and go long on a future contract.

Additionally, Equation 3.1 emphasises the implications of convenience yield in linking spot and future prices. As stated by Pindyck (2001), the relationship between spot and future prices is a function of risk free interest rate and net (of storage cost) marginal convenience yield. If the marginal convenience yield is positive then the term structure of future shows normal backwardation, meaning that the spot price is more expensive than future price. On the other hand, if the marginal convenience yield is negative, the future term structure is in contango and future prices exceed spot price. Contango and Backwardation, changes in the term structure of commodity derivatives and maturity spread are depicted in Figure 3.6 which shows the difference between the spot price and a future contract on wheat (maturity 15 months).

**Figure 3.6** Spread between spot price and 15 months maturities US wheat futures. Data Source: Thompson Reuters database.



The lines moving into negative territory show that commodities for immediate delivery is more expensive than those for delayed deliveries – indicating backwardation, a negative premium for future delivery. Usually, storable commodity markets are in Contango that reflects a storage cost for future delivery. Backwardation refers to the phenomenon where

a commodity for immediate delivery costs more than for later delivery: it is something one would not expect to see if supplies were high. Under equilibrium conditions, the backwardation of term structure implies that holding the commodity entails benefits or convenience which is not present in the future ownership (Hull, 1997).

This situation is caused by another important cost borne by investors present in Equation 3.1: the opportunity costs of storing a commodity which is represented by the interest rate term  $i$ . The opportunity cost precludes the possibility to invest in another asset, buy a future contract on the commodity needed and receive it at date  $t+T$ . Thereafter, this opportunity cost is influenced by the level of interest rate: when interest rates are high, it is more convenient to invest in risk free instruments, buy a future price on the commodity, and leave the cost of storage to someone else and gain from the high level of interest rates. Given the important role played by the storage activity and convenience yield, a wide stream of academic literature claims that interest rates (Frankel, 2008; Akram, 2009) and exchange rates (Chambers, 1984; Bessler and Babula, 1987; Bradshaw and Orden, 1990) are the main determinants of cycle and fluctuations in commodity markets.

As Irving Fisher suggests in his book "The Theory of Interest", the nominal interest rates must equal the marginal rate of return on capital plus the expected rate of growth of price level (Fisher, 1930). This model was used by Fisher to give an explanation of the Gibson's Paradox: a cumulative rise in commodity price generates expectations of a further increase which makes investors willing to hold bonds only at lower prices, which creates a period of high prices and interest rates. This is known as the Gibson's Paradox recalled by J.M. Keynes in his work "A Treatise on Money" where he, firstly in the economic history, against the common believes states that the level of real interest rate are positively correlated with the general level of prices (Keynes, 1930).

Over the last two decades the role of commodity markets and its linkage with monetary policy and inflation rate has been widely discussed in economic literature. Commodity

prices and inflation links are very important for two main reasons; first, commodities are often viewed as inflation hedging tools that protect real purchasing power of market participants (Gorton & Rouwenhorst, 2006). Secondly, they reveal a lack/abundance of investments in commodity industry (Jacks, et al., 2010). A generally accepted view (Popkin, 1974) suggests that an increase in commodity price leads to an increase in production cost, which will create a pressure on prices therefore causing an increase in inflation (Marquis & Cunningham, 1990; Fuhrer & Moore, 1992). Some economists argue that commodity prices are leading indicators of inflation because they promptly respond to the macro-economic environment (Bloomberg & Harris, 1995; Verheyen, 2010). Despite the general view that commodity price swings lead to inflation changes, the causal relationship between inflation and commodity prices is not thoroughly understood. However, causality plays an important role in these circumstances: as Frankel (1986) argues, commodity prices are subject to the underlying changes in interest rates, thus they incorporate inflation expectations faster. Commodities are assets that do not pay dividends or coupon to the holder; therefore, the expected commodity return is given by the expected price increase, minus the carrying costs which includes a risk and interest rate premium too. Thus, in response to a fall in interest rates, current commodity prices would rise more in (percentage terms) than expected prices, i.e. overshoot, to ensure that the expected increase in commodity prices equals the lower real interest rate (and carrying costs) (Frankel, 1986). Additionally, as will be discussed in the next section, an interest rate hike increases the cost opportunity of holding inventories thus leading to a contraction in the general level of commodity stocks.

### **3.4 Commodity prices and speculation**

The announcement by the monetary policy institution of changing the level of interest rate affects the storage decisions of commodity market players: *ceteris paribus*, an increase of interest rate raises the costs of storing the commodity (and the related opportunity costs), causing a decrease in inventories demand. This inventory demand drop creates

downward pressure on commodity prices because part of the supply is not absorbed by the market for inventories purposes, leading to a temporary over supply which reduces the general level of prices. Belongia and King (1983) find a statistical relationship between the rate of growth of the money supply and commodity prices. According to this view, commodity spot and future prices are always very flexible and they change continuously in response to interest rates changing, affecting the expectations of market participants regarding the current supply and expected future supply (Bond, 1984). As Barnhart (1989) states, surprises in monetary policy cause changes in commodity prices: he demonstrates that a basket of twelve commodities respond negatively to any money supply whereas the responses of t-bills yields are positive. Given this framework, it is possible to understand why interests rates are so important in determine the supply and demand quantity in commodity markets. Frankel (2006) emphasises that interest rates and commodity price are strictly linked; in particular an increase in interest rates influence commodity prices through three channels:

1. They give an incentive for extracting more today rather in the future;
2. They decrease the convenience of keeping inventories;
3. They decrease the willingness to hold inventories because of the cost opportunity of investing in Treasury Bonds rather than "*buy and hold*" physical commodities.

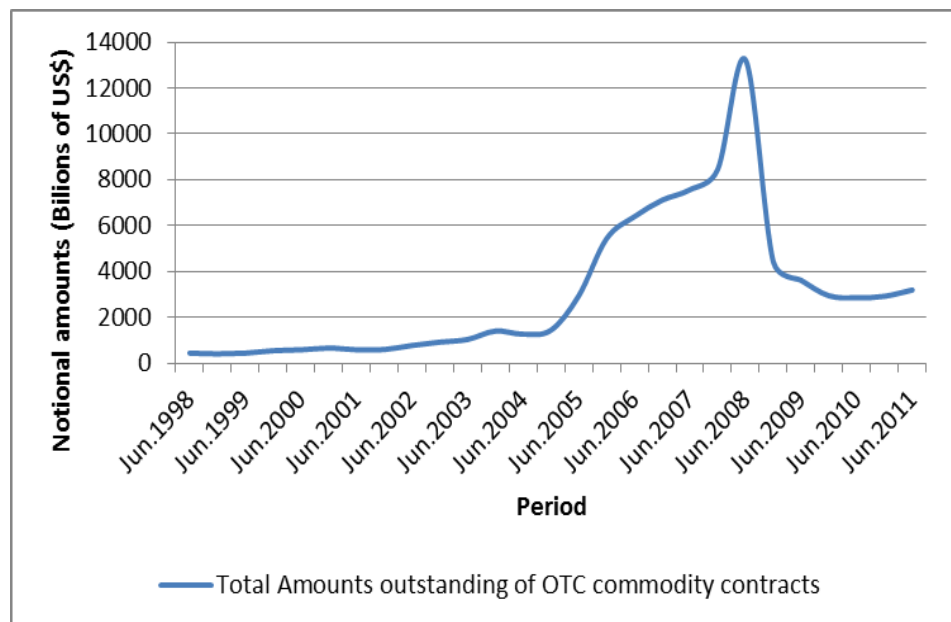
Although Calvo (2008) emphasises that money supply shocks are only a temporary shock and prices should adjust in the long term, Farooq Akram (2009) estimates a structural VAR model and he finds that commodity prices increase significantly in response to reductions in real interest rates. The evidence also suggests that a weaker dollar leads to higher commodity prices. Shocks to interest rates and the dollar are found to account for substantial shares of fluctuations in commodity prices (Farooq Akram, 2009). From evidence there are some common patterns in commodity and interest rate behaviours; when interest rates increase - and stocks related to higher interest rates tend to go down, just as bonds go down – then commodities tend to increase and inflation expectations

raise accordingly. For example, during the 1970s, when commodities started to increase the prices bonds and stocks declined, making them the worst possible investment in the finance industry (Frankel, 2006).

The relationship between commodity prices, interest rates and exchange rates has made commodity market appealing to investors seeking new opportunities to hedge, diversify and leverage their portfolios in the era of low interest rates (Georgiev, 2001). Additionally, over the past 20 years, a marked decline in interest rate has pushed investors to pile their money into commodities, on the expectation that inflation would soon appear thus profiting from a shift in commodity prices. Given these market changes, commodity derivatives have become a more important business operational tool for producers too: first, they enhance risk management, second, they enable future price discovery and third, they provide higher liquidity to markets that have historically been characterised by low levels of transactions.

According to this background, commodity markets have become a new asset class and, in recent years, the number of commodity financial contracts has grown steadily, in particular derivatives and over the counter products (Figure 3.7).

**Figure 3.7** Total amount outstanding of OTC commodity contracts. Data Source: IMF-BIS database.



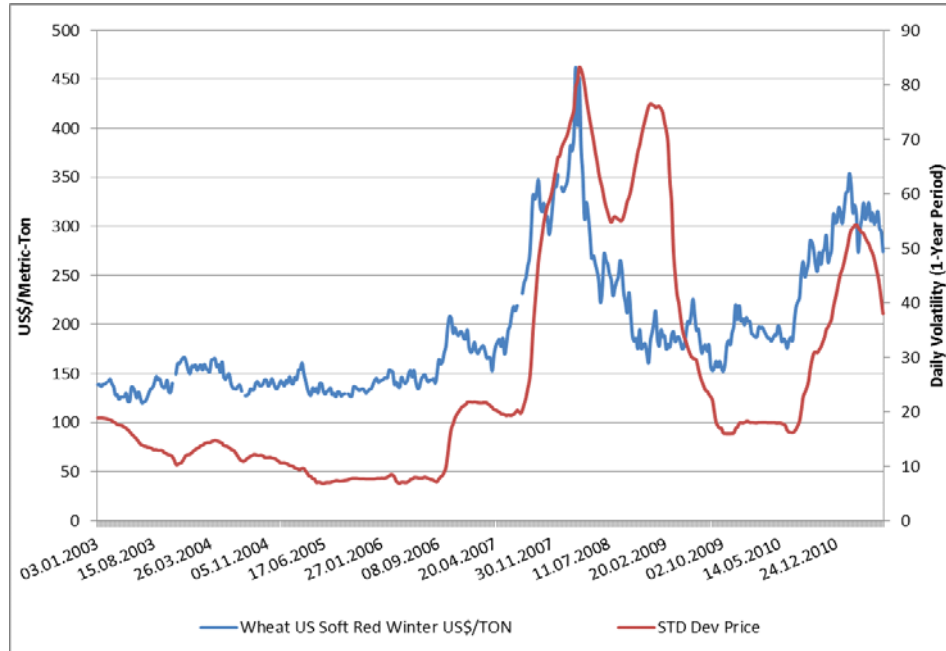
A derivative is a financial product that is valued depending on another asset, called the underlying asset. More straightforward, a financial derivative "derives" its value from an underlying asset. In the case of commodity derivatives, the derivative future contract derives its value from the behaviour of the spot price according to the Equation 3.1 presented in Section 3.3. More recently, a large variety of commodity derivative contracts have been added in order to respond to the different needs of investors and farmers: option (call and put), spread options and calendar spread options (Chicago Mercantile Exchange, 2015). Over the past ten years, the presence of financial investors has become more intense and their presence has contributed to deeper markets which should in turn diminish fluctuations and reduce short term volatility (Domansky & Heath, 2007). Moreover, the role of these market participants is very important since they act as the main counterparties in order to absolve at the main function of commodity derivative markets: the function of price discovery.

However, between 1997 and 2010, volatility was higher, for most commodity prices than during any other period before (European Commission on Agricultural and Rural Development, 2011). Owing to these recent trends, there has been much debate on



speculation in commodity markets and the role of institutional investors operating in these markets.

**Figure 3.8** Prices and standard deviation of US wheat. Data Source: FAO database.



After the last commodity spikes, it was pointed out that the fundamentals do not justify such price patterns, and some researchers argue that the “financialization of commodity market” and the presence of commodity index investment have put pressure on the mechanism of price formation and caused a speculative bubble in these markets (Masters, 2008). In the financial industry during the last decade, there has been increasing attention given to the commodities market as a new kind of asset class. In the search for increasing levels of diversification, different funds and investment banks began to include commodity assets in their portfolios, such as grains, metal and energy-linked derivative products.

Robles et al. (2009) argues that the sharp increase in commodities cannot be explained merely by supply and demand fundamentals; they claim that speculation, expectations and hysteria drove up prices and increased volatility on commodity markets. Calvo (2008) claims that commodity price growth derives from a combination of low interest rates, growth of sovereign wealth funds and a lower demand for liquid assets; however, he

argues that this relationship is temporary and prices will revert to their path in the long run. Baffes and Haniotis (2010) state that the effect of high liquidity (namely a long period of low interest rate) and the effect of this liquidity could have led to speculation which may be the cause of the steep increase and decrease in commodity prices.

In 2008, Masters expressed his concerns to the Committee on Homeland Security and Governmental Affairs in the United States Senate, by stating that rather than a shock on the supply side of the market, commodity markets experienced a demand shock stemming from a new category of participant in the futures market: pension funds, sovereign wealth funds, and other institutional investment (Masters, 2008). Those, he called "*Index Speculators*", to distinguish them from speculators, who have always been trading on commodity markets, have a greater impact on prices because commodity markets are much smaller than equities markets and money inflows are more significant. In the follow up to this stream of literature, the real problem behind soaring food and commodity prices seems to stem from society's failure to recognise the importance of its "needs" relative to its "wants" over the last 30 years.

Despite aforementioned evidence, a wide spectrum of literature refutes the boom-and-bust assertions and supports the thesis of any speculative behaviour. Krugman argues that the sharp increase in commodity prices stems from demand changes, inventory shortages, and supply shocks (Krugman, 2008). Pirrong (2008) demonstrates that no evidence supports the thesis of distorted prices and concludes that the speculation did not lead up to the spikes in commodity markets. Irwin et al. (2009) test whether the presence of index funds on commodity markets drove up prices between 2006 and 2008. They find that index fund positions do not affect returns across markets which, in their opinion, would reject the evidence of a bubble in the commodity market. In another article, Irwin and Sanders (2010) find evidence for a negative relationship between the presence of investment funds in commodity markets and volatility, and suggest that regulating the

presence of investment funds in commodity markets may raise liquidity problems (Irwing & Sanders, 2010).

### 3.5 Conclusions

Commodity price behaviour is a very complex issue in economics and finance. Their prices are influenced by several shocks which can induce instant changing to their path. The steady rise in global commodity prices has been determined by a combination of cumulative shocks, more recent supply and demand dynamics, and governmental policies (Zhang, et al., 2010). However, Masters (2008) argues that the sharp increase in commodity prices was caused by large inflows of investment coming from hedge funds, investment banks and “*index speculators*”. Despite the unresolved debate over commodity speculation, Pirrong (2008) shows that aggregate stocks of major commodities declined to minimal feasible levels in 2007–2008. Given these minimal stocks, commodity prices were very sensitive to shocks (Timmer, 2008). An important feature of commodity prices behaviour is (1) the rigidity and (2) the uncertainty. In other words, (1) supply and demand are inelastic function of prices; and (2) supply may abruptly change (weather conditions, crop or transportation failure) and demand might structurally change (GDP growth, changes dietary habits, and population increase).

In such markets characterised by rigidity and uncertainty, it is useful to understand the role of inventories and recall the importance of Storage Theory (Kaldor, 1939). This theory emphasises the role of inventories as a buffer to sudden changes in market conditions and seeks to address the problem of non-convergence between spot and future prices (Spot-Future price spread). If inventories are set at a minimal level any shock, including weather changes, export bans or financial speculation can trigger a boom and bust cycles that has catastrophic effect over the global production chain of commodities. Although the drivers responsible for the commodity peak to through cycle are yet unknown, we know that there are a numbers of forces playing behind the stage curtains of commodity markets. By influencing commodity prices, these forces have nonlinear effect over other

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global economic variables: the volatility generated on commodity market spills over to other connected markets and first among others is the maritime industry. In the maritime industry freight rates are determined on the market through the interaction of supply and demand: Tanker and dry Bulk Indexes are the most important benchmarks for freight rates world-wide; they are traded in organised markets such as the Baltic Exchange (Stopford, 2007). Between 2007 and late 2008, similar to commodity prices, dry bulk freight rates have recently begun to follow a roller coaster behaviour, with sharp growth and steep drops combined with high volatility (Nomikos & Alizadeh, 2009). The relevant interrelation to commodity markets raises the question of whether speculative effects took place in the dry bulk industry. Against this backdrop, the aim of the following Chapter is to investigate whether a similar speculative cycle took place in the maritime industry; in doing so, the Chapter will analyse the market segment dedicated to commodity shipments: the dry bulk sector.

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## **Chapter 4      Identifying speculative bubbles in dry bulk freight rates**

### **4.1 Introduction**

Chapter 3 described two important factors affecting commodity markets: the role played by inventories to curtail excessive price swings and the recent financialization of commodity markets. Chapter 4 examines a service closely connected to commodity trade, which has the characteristic of being non-storable and has recently attracted the attention of financial investors: dry bulk cargoes.

The dry bulk industry plays a vital role in international trade and is a remarkable example of an earnings driven market which attracts a well-diversified class of investors in particular due to the generous profits that are generated (Stopford, 2007). It has been claimed that dry bulk freight rates is the new commoditised asset class for global speculative investors and it has experienced an increasing level of attention from risk seekers to further diversify their portfolios (Geman, 2005).

As described in Geman and William (2012), the shipping market is a particular type of commodity characterised by non-storability, seasonality and a strong correlation to the international merchandise trade hence to the performance of the global business cycle. This makes freight rates very dynamic, volatile and prone to boom and bust phases that sometimes assume the pattern of speculative bubbles (Binkley & Harrer, 1981). However, the boom and bust phase experienced by dry bulk freight rates between 2005 and 2010

has created a large debate regarding the presence of speculative behaviours in shipping markets.

As freight rates are the main source of income for maritime companies they play a pivotal role in signalling period of investments in shipping industry; in boom period, earnings are growing steadily and the share prices of dry bulk listed companies are at their maximum. The combination of these factors leads to the perfect economic environment for dry bulk companies to gain access to credit and thus increasing their corporate leverage. When the freight market peaks and then collapses, many maritime firms are not able to fulfil their credit obligation and file bankruptcy. This is particularly true for large corporations: according to Alix Partners Dry Bulk Shipping Outlook (2016) six large dry bulk carriers filed for court protection while many others pursued debt restructurings (Alix Partners, 2016). On the other hand, it is interesting to notice that although large listed dry bulk companies have struggled to finance their debt positions due to the combination of large investment and low freight rates, many small ship-owners that holds large cash positions on their balance sheets were able to navigate through distressed periods and survive in the an environment of low earnings.

In response to this situation, governments and policy makers have sought to identify causes, consequences and innovative ways to curtail speculation and its appalling consequences over the global economy. Therefore, there is the need to create a rational background and a methodology to evaluate whether speculative activities take place in dry bulk industry.

Given this background, Chapter 4 investigates whether a speculative effect was present in the dry bulk shipping market between 2005 and 2009. A theoretical methodology will be presented to assess the presence of speculative activity in dry bulk freight rates and will be evaluated the extent to which these boom and bust periods influence the market dynamics. According to these objectives, the remainder of Chapter 4 is organised as

follow: Section 4.2 reviews the dry bulk industry and presents the key characteristic of freight rates. Section 4.3 introduces speculative bubble in the context of dry bulk freight rates and provides a preliminary analysis of the boom and bust cycle in the dry bulk industry; Section 4.4 develops a global multi-factors model to test speculation in dry bulk freight rates; Section 4.5 back-tests the research results and critically examines the main research findings; Section 4.6 concludes the chapter, draws conclusions and provides some policy recommendations.

## **4.2 The dry bulk industry**

In the context of international trade, nations exchange goods with each other and trade is a common feature of the specialisation and division of labour (Smith, 1776). Nations can exchange raw materials (such as iron ore, copper, wheat, soybean), semi-manufactured goods and final goods. Commodity markets represent the fuel of global economic performance: they are the market places where supply and demand meets and, as a result, the prices of raw materials are determined.

Since the beginning of modern history in 1492, the trade of commodities has strictly been linked to transport. People engage in trade because they want to consume goods or commodities that are not available in their national/regional endowments or may be available in another part of the world because of its own competitive advantage (Thisse, 2011). The most suitable means of shipping commodities from one region to another around the world has always been via sea vessels and the pace of movement of raw materials via sea is seen as a leading indicator to the health of global trade and economic growth. In Particular, dry bulk is the segment of the maritime industry in charge of shipping the main raw materials all over the world. As well as the commodities trade, the dry bulk freight market has grown fast over the past decades sustained by the explosion in global trade and developments in the maritime industry. UNCTAD classify seaborne trade under four main types of vessels, linked to the characteristics of the cargo shipped (UNCTAD, 2004):

1. Oil Tanker;
2. Bulk Carriers;
3. General Cargoes;
4. Container Ships;

Oil tankers refer to general carriers of crude oil and any other linked products. General cargo includes refrigerated cargo, specialized cargo, ro-ro cargo, general cargo (single- and multi-deck), and general cargo/passenger. Container ships carry their entire load in truck-size intermodal containers. Bulk carriers' states for the means by which a group of six main commodities are shipped all over the world, namely iron ore, grains, coal, bauxite, aluminium, and phertilisers.

In particular, bulk vessels carry dry (grains, fertilizers, phosphates and iron ores) or wet (chemicals, orange juice, refined petroleum products) bulk commodities. The dry bulk industry is formed by four main types of vessels:

1. Capesize (172000 DeadWeight Tonnage (DWT) and above) comprising 10% of the world fleet;
2. Panamax (74000 DWT) ) comprising 19% of the world fleet;
3. Handysize (45000 DWT);
4. Handymax (28000 DWT) comprising 34% and 37% of the world fleet respectively.

The first 172,561 DWT Capesize vessels was designed by NKK Corporation, built by Tsuneishi Shipbuilding/Hashihama Shipbuilding, and delivered, in September 1999, to Louis Dreyfus Armateurs, a major trading house. These vessels are too wide to transit the Panama Canal (indeed, the capesize name derive from this and, generally, this term means all the vessels exceeding 85,000 DWT); they achieved the maximum hold capacity and DWT within the limitation of the Port of Dunkirk. Capesize vessels are used to



transport mainly iron ore and the routes covered are South America and Australia to China and Japan, Western Europe and North America and much more rarely coal from Australia and North America to Japan and West Europe. They are characterised by deep draught and a small number of commodities that they can carry and so far the operation of these carriers in terms of trading routes is fairly restricted. These carriers have a deeper draught and engage in transportation of fewer commodities than the Handysize fleet; therefore they are less flexible than small size vessels. Moreover, they are always gearless (as they are too wide to fit cranes). As will be shown in Chapter 6, in particular in iron ore carriers, a recent development has pushed further the developments in holding capacity and the new Very Large Ore Carriers (VLOC; 200,000 DWT) benefits from economies of scale and greater efficiency in handling raw materials characterised by a price to volume ratio very low.

Whilst the first Panamax vessel designs of around 60-65,000dwt were designed in the late 1970's, the first 75,933 dead-weight-tonnes (DWT) Panamax bulk carrier (known in shipping circles as an LME – Large-Modern-Economical Panamax) was built in 2000, at Kanasashi Co. LTD. These vessels carry mainly coal, and grain but are sometimes used in iron ore transportation as well. Cargo space is divided into seven holds topside tanks and double bottom with side hopper. The fourth cargo hold can be used as a ballast tank and they are usually gearless, with a breadth of 32.20m, sufficient to pass the Panama Canal safely. The main routes in which they are used are from North America/Australia to Japan and West Europe but also from East Coast South America to both Europe and the Far-East.

The vessels between 20,000 and 50,000 DWT are further divided into Handysize (25,000-40,000 DWT), Handymax (40,000-50,000 DWT), Supramax and Ultramax (50,000-62,000 DWT). The Handysize carriers are mainly engaged around the world in the transportation of grain commodities from North and South America, Australia to Europe and Asia, as well

as other minor dry bulk commodities which could be even dirty (Bauxite, alumina, fertilisers, scrap, steel products, rice and sugar).

Because of the nature of the product and goods shipped, the dry cargo chartering market cannot be rigidly divided into segments; however, it is possible to identify two stages in which charter activity takes place: local and world wide business. The dry cargo industry has indeed several divisions, according to ship type and size, commodity shipped, and geographical markets. The only physical market place for chartering dry bulk ships is the dry Bulk exchange in London. Market practitioners in these markets can be divided under the following categories:

1. Charterers: those who want to charter a ship to carry commodities;
2. Ship-owners: the counterparty who owns the vessels;
3. Operators: organisation that creates revenues from trading ships and cargoes;
4. Shipbrokers: the brokers working between the three counterparties listed before.

There are four main types of contract in the dry bulk industry: time charter (TC), voyage charter (VC), bareboat charter, and contract of affreightment. Time charter is a contract for the hire of a vessel under which the vessel owner is paid a charter rate on a per day basis for a certain period of time. The ship-owner is paid, in advance, of regular amounts of money, on monthly or semi-monthly basis. The vessel owner is responsible for providing the crew and paying operating costs: while the charterer pays for the voyage costs (including bunkers), the charterer is responsible for any delays at port or during the voyage, besides certain exceptions such as loss of time arising from vessel breakdown and routine maintenance. Whereas, in VCs the charter bears few responsibilities (stevedoring, cargo handling, and cargo insurance) and this type of contract enables a more balanced division of responsibilities between the ship-owner and charterer (Table 4.1).

**Table 4.1** Time Charter contract responsibilities

<i>Ship-Owner</i>	<i>Charter</i>
Crewing	Employment
Repairs, Maintenance and Spares	Bunkering
Classification and Surveys	Port Expenses and Canal Tolls
Insurance of Vessels	Stevedoring
Stores and provisions	Cargo Handling
Heating and Cooking	Insurance of Cargo
Lubricating Oils	Insurance of Bunkers

A voyage charter is when a vessel is employed for a single trip; it is a contract for the hire of a vessel under which the vessel owner is paid freight on the basis of moving cargo from a loading port to a discharge port. The operator is responsible for paying both operating costs and voyage costs and the charterer is typically responsible for any delay at the loading or discharging ports. Spot rates are defined as the rates in dollar per ton (\$/ton) or dollar per day (\$/day) for a specific trip from port A to port B. The spot charter rates are thought to be determined by current supply and demand for shipping services and other financial-economic variables (Stopford, 2007). Bareboat charter is contract for the hire of a vessel under which the vessel owner is usually paid a fixed charter rate for a certain period of time during which the charterer is responsible for the operating costs and voyage costs of the vessel, as well as arranging crewing. Contracts of affreightments (COAs) are arrangements under which a ship-owner (or an operator) agree terms for the carriage of a given quantity of commodity on a specified route, on a regular basis. COAs are long lived (at least 3 years up to 15 years). In this agreement the counterparties specify only the cargo, the ports of origin and destination, and the service. They are often priced with the mechanism of variable cost (i.e., fuel plus the crew) plus a fixed payment which can be related to an index of spot freight rates. The total volumes of cargo to be carried may require the vessel owner to use several different ships to fulfil such.

After having reviewed the different type of contracts, it is observed that the dry bulk cargo industry is primarily characterised by tramp vessels that haul large quantities of raw materials (grains, iron ore, copper, and coal) from regions of extraction/harvest to regions of production. Given the characteristics of the dry bulk service, variations in freight rate are caused by several factors such as regional growth, routes, fleet size, tonnage shortage in loading areas and an oversupply of vessels in discharging zones (Xu *et al.*, 2011). Binkley and Harrer (1981) show that larger vessels lead to lower at-sea costs and a negative correlation between the volume traded and the route. The influence of geographical imbalances in the dry bulk market is confirmed by Laulajainen (2007), who examines freight revenues and demonstrates the importance of loading and unloading regions in the definition of freight rates. Moreover, in relation to freight rates, we need to consider its peculiar distribution and dispersion because of the intrinsic characteristic of the shipping market; namely, that it is perfectly competitive and that services exchanged cannot be traded and stored (Kavussanos and Visvikis, 2006).

Competition, infrastructure developments and technology improvements have caused a reduction in freight rates and consequently increased the trade between countries, in particular of those materials, such as raw material which might have low ratios weight/value (Lundgren, 1996; Hummels, 2001; Limao & Venables, 2001). Additionally, Hummels *et al.* (2009) suggest that the shipping market structure is a key variable for the level of freight rates: they show that there is price discrimination for value of materials carried, the import demand elasticity, and the tariff levied on goods. Sanchez *et al.* (2003) demonstrate how port efficiency increases country competitiveness and reduces the cost for shippers. A well-known paper by Limao and Venables (2001) shows how efficient infrastructures are one of the most important developments to be achieved in order to enable reduction of transport costs and in freight rates with consequent positive effects on the level of international trade.

On the other hand, the exposure of the shipping industry to the performance of the global economy poses further challenges in the understanding of freight rates swings. Given the interactions between international trade trends and shipping markets, the macro-economics determinants of dry bulk freight rates have been studied broadly in literature. Stopford (2008) suggests that dry bulk freight demand is a multidimensional interaction between commodity markets, international seaborne trade and global economic output. On the same line, Chiste and Van Vureen (2014) study the influence of the business cycle on the performance of dry bulk freight rates and they demonstrate the synchronicity of dry bulk cycles with the global economic behaviour. Following a similar approach, Kavussanos and Alizadeh-M (2001) addressed the problem of the macro-economic seasonality across freight rates of different size vessels and contract durations (spot, 1-y and 3-y time charters): they find that freight rates in the dry bulk market have regular seasonal patterns and similarities across vessel size and contract durations.

Given the multidimensional interactions affecting dry bulk freight rates, the level of competition and the non-storability characteristics of the service traded (i.e. the freight rate itself) the market remains prone to boom and bust phases. In fact, the dry bulk sector is a very volatile market driven by regional factors and global imbalances. The intrinsic characteristic of being the means by which the raw materials are shipped all over the globe leaves the shipping industry prone to fluctuations, spikes and steep downturns associated with the behaviour of global economic activity and the price of the goods shipped (Pettersen, 2012).

The industry in recent years has been able to develop financial tools to hedge and offset such risks but the pricing of these derivative contracts implies a good understanding of volatility mechanisms in dry bulk freight markets (Kavussanos & Visvikis, 2004). The first attempt to develop a derivative market on freight rates occurred in the middle of 1980s. BIFFEX started trading on LIFFE in 1985 and ceased to exist in 2001 due to low levels of liquidity. The key problem for those derivative contracts was the specification of the

underlying price. Indeed, the Baltic Freight Index (BDI) is a weighted average of spot prices on different routes. The weighting and the composition of this basket of routes is subject to changes over time (Kavussanos & Nomikos, 1999). If a market player wants to hedge from a risk on a specific route in a specific commodity it could not do so: there was a lack of flexibility, the standardisation of these contracts led to illiquidity and BIFFEX was forced to shut down (Dalheim, 2002). On the other hand, the OTC contract called Forward Freight Agreement (FFA) grew steadily from 2000 to 2010. FFAs were developed by Clarksons and Co Ltd and these contracts are similar to a swap “with a defined future period where spot freight rates are swapped against a fixed rate determined today”. At the end of 2001 a new clearing house developed a market for future contracts in shipping freight rates: IMAREX.

FFAs offer to ship-owners, charterers and traders a means of protecting themselves against the volatility of freight rates. Contracts are agreed between counterparties of the contract and are cleared with clearing houses such as LCH.Clearnet (London), SGX (Singapore) or NOS (Oslo). The derivative market on dry bulk freight rates has developed strongly in the last years and nowadays it is possible to find FFA contracts on all types of dry bulk cargo with different time to maturities. Many developments in the maritime industry have become feasible thanks to improvements in contracting, negotiating and hedging risks through contracts and improvements in services provided. Consequently, freight rates may be considered as a key component of the commodity market with the inherently characteristic of non-storability (Geman, 2005). However, this can be viewed as a cost of services, instead of a raw material devoted to the production of goods. In fact, unlike commodities, freight rates have the property of not being storable and, as a result, the market is more volatile: in periods of boom and bust there are not inventories capable of absorbing short term shocks.

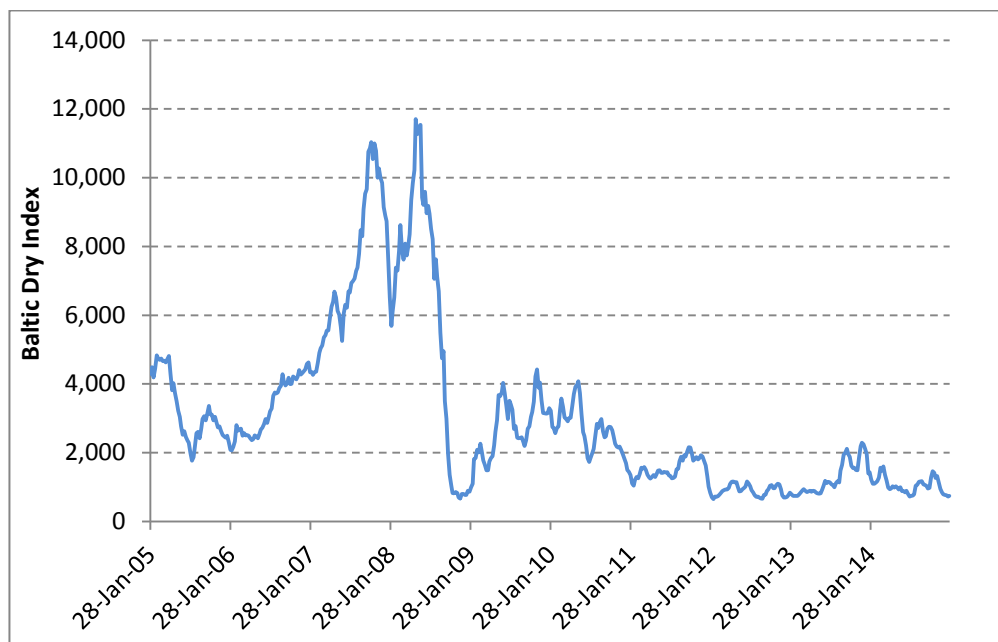
The shipping freight rates and derivatives are traded daily in central exchanges and they are a leading indicator of the industry's health thus driving investment decision, second

hand market and building or scrapping activities. More recently, a number of institutional investors have started to look at the Shipping Market in order to find innovative ways to diversify their portfolio and provide a source of return in the era of low interest rates. However, the non-storability of the service combined with the high degree of uncertainty creates a fertile ground for periods of investment euphoria or depression, thus leaving the market prone to speculative investment periods.

### 4.3 Identifying dry bulk speculative bubbles

As mentioned in Section 4.2, the shipping industry is a very dynamic and volatile environment where freight rates can experience periods of high inflation and unpredictable collapse. As Figure 4.1 shows, dry bulk freight rates are prone to periods of spikes, acceleration in the growth level of freight rates and contractions. For Geman (2009), this peculiar element is linked to the non-storability of the asset under investigation which tends to exacerbate fluctuations, peaks to through phases and volatility (Geman, 2009).

**Figure 4.1** Baltic Dry Index. Data Source: Thompson Reuters database.



Nevertheless, it is between 2005 and 2010 that dry bulk index has experienced the largest fluctuations of the last two decades. In August 2005 the Baltic dry index traced its

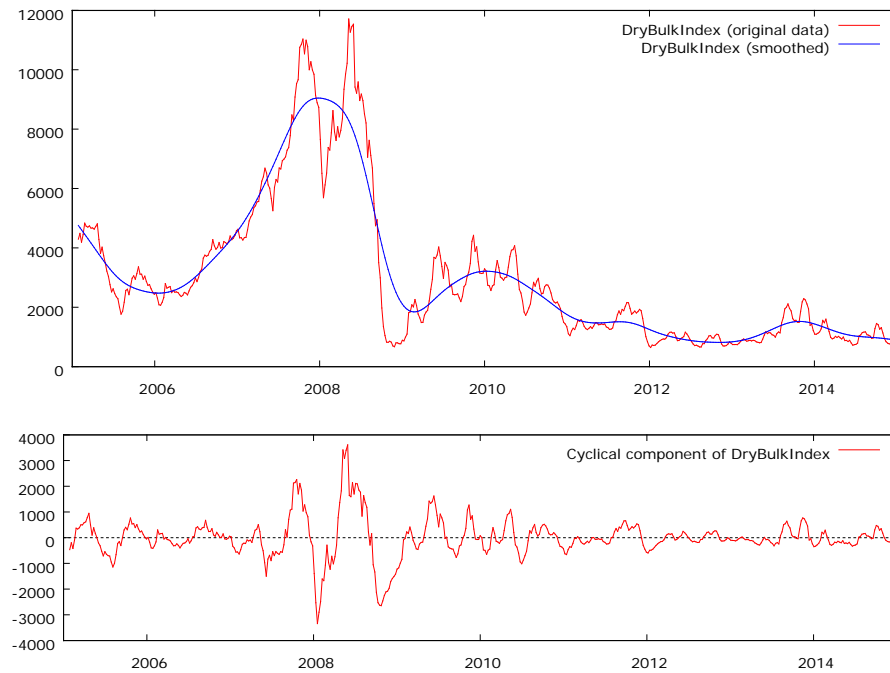
minimum low at 1,769 point and started a dramatic climb to the top, reaching 11,534 in June 2008. Over the span of these 3 years, the volatility of dry bulk index was very low: the average level was 0.36 ranging from a maximum of 0.54 to a minimum point of 0.29. As volatility can be considered an adamant index that reflects risk for investors, it is stated that low volatility periods increased the appealing of freight rates as safe investment associated with high returns and low risk. The combination of low volatility and high returns boosted the consumption of freight rates as an asset class and therefore has reduced sharply the freight rates increase towards its maximum of the last two decades.

The month of June 2008 had been the main turning point for the dry bulk industry and the impact of global crisis on international trade created the perfect storm to finally burst the bubble. In a matter of a few months, the dry bulk index plunged from 11,534 point to 772 point in January 2009. The drop in freight rates created a generalised panic in the shipping industry and this effect is well stated in the volatility index for dry bulk freight rates; during this period of time, volatility peaked to its historical maximum over the last ten years with an average of 1.02 and a maximum of 1.3.

In order to provide a more sophisticated picture of the freight rate boom and bust cycle, the long term and the cyclical components in freight rate are separated by using the methodology suggested in Hodrick and Prescott (1997). The Hodrick Prescott methodology is in the form of double-side moving average filter which is able to detect the long period trend and separate any transitional component in the form of cyclical, speculative and transitional effects (Hodrick & Prescott, 1997). As Figure 4.2 shows, the Hodrick Prescott filter analysis depicts how the boom and bust between 2005 and 2010 was an exceptional period out of any other fluctuations of the last years.



**Figure 4.2** Hodrick-Prescott filter: an application to dry bulk index. Data Source: Thompson Reuters database.



According to the cyclical component plot shown in the second graph of Figure 4.2, it is possible to detect the exceptional peak to through phase between 2006 and 2008; furthermore, the graph emphasises the large fluctuations that have been generated after the boom period where a period of high volatility characterised freight markets between 2009 and mid-2010. The large fluctuations depicted in this figure are the noise and the large level of risk that was perceived by dry bulk market makers after the collapse of prices in June 2008.

Given this time line of events, the dry bulk boom and bust phases are separated in two components: the “boom”, ranging from August 2005 to June 2008 and the “bust” phase from June 2008 to February 2009. The periods were divided into boom and bust by taking the lowest to highest and highest to lowest of the variable under scrutiny. Although, this seems a simplistic backward looking approach, it is the one that at this stage of the analysis allows to slice and dice the cycle without losing any time of relevant information. Other methods are applicable to detect trend reversals (Moving Averages Short vs Long, Structural Breaks and Variance analysis) however they all have the features of being

backward looking with the additional drawback of decreasing the data point available for the descriptive statistics. The data of the dry Bulk Index (Baltic dry Index) is collected from Thomson Reuters database and the descriptive statistics of the two periods are presented in Table 4.2.

**Table 4.2** The boom and the bust phase: descriptive statistics.

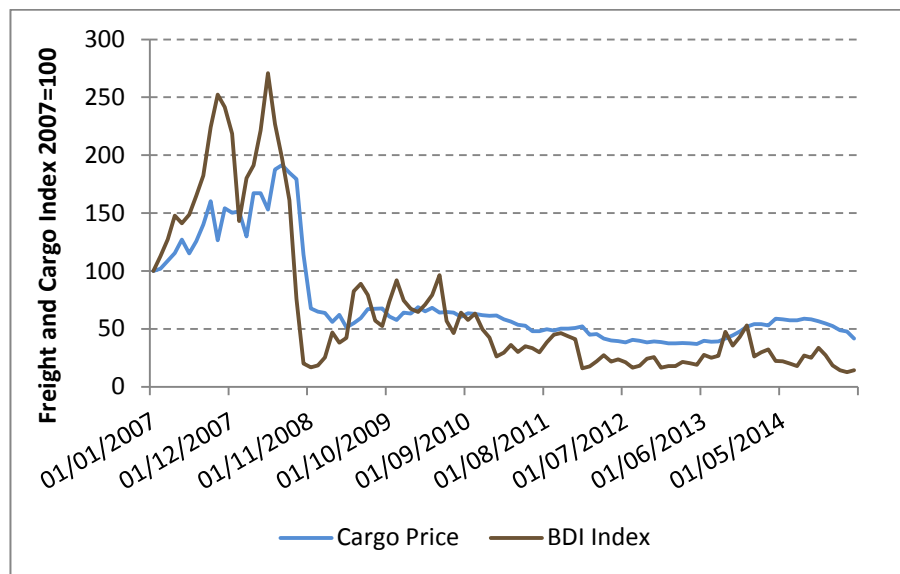
	<i>Boom Phase</i>	<i>Bust Phase</i>
Number of weeks	128	40
Mean	0.011	-0.046
Median	0.013	-0.035
Minimum	-0.202	-0.414
Maximum	0.183	0.501
Std. Dev.	0.061	0.169
C.V.	5.896	3.651

The first thing to notice is that the boom period is longer lived than the bust: the dry bulk expansion lasted 128 weeks whereas the contraction phase only 40 weeks. In total, the boom period accounted for 76% of the speculative cycle whereas the bust for only 24%. This is common to many other speculative patterns where a prolonged period of positive returns is followed by a sudden, steep and very short lived decrease (Komaromi, 2006). The average return during the boom phase was on average 10% on a weekly basis with a standard deviation of 0.061. On the other hand, the return in the bust phase was on average -4% with volatility conspicuously higher around 0.17. The presence of a period of high returns and low risk followed by a period of negative returns and high risk has been reported to be a first symptom of speculative cycles and in particular when extreme values take place (Malpezzi & Wachter, 2002). This is a typical pattern in speculative periods: returns and asset prices change their normal development path towards an explosive dynamic growth, which creates a wide spread investment exuberance that fulfils itself by

attracting more investors, thus further inflating asset prices (Allen & Gale, 2000) (Liu, et al., 2013).

Given this preliminary background information, this research specifies a model to comprehensively evaluate the presence of speculative bubbles in dry bulk industry. It employs an extensive dataset which accounts for two key variables in the industry, namely the freight rates (Baltic Dry Index, “BDI”) and the cost of purchasing a new build cargo (Bulk Dry Cargo - Selling Price Index). The Baltic Dry Index dataset is provided by Thompson Reuters and is the composite weighted of the Baltic Capesize, Panamax, Handysize and Supramax indices. The Bulk Dry Cargo index is a composite weighted index for the price of new built vessel in the market and is created by VesselFinder.

**Figure 4.3** Bulk dry cargo selling index and BDI. Data Source: Vessel Finder database.



As shown in Figure 4.3, the Dry Cargo Price Index and Baltic Dry Index have experienced large movements after 2007. However, the time series plotted in the chart emphasise a switch in the behaviour of price changes: between 2007 and 2008, BDI has grown at a faster rate in respect to Dry Cargo Prices whereas after 2010 BDI witnessed a period where it couldn't trace back the pace of the Cargo Index.

In order to fully describe the relationships between the two indexes and verify if speculation occurred, the study uses an analytical model which is able to identify and separate the bubble component from the fundamental value of the asset. For this purpose, the econometric time series analysis provides a preliminary test to verify the presence of speculative pattern in asset pricing. According to Blanchard and Watson (1982), a speculative bubble is when the security price diverges from its own fundamental values. Examples come from stock prices and dividends (Flood & Hodrick, 1990), real estate prices and rent values (Cocconcelli & Medda, 2013), commodity prices and macro fundamentals (Du, et al., 2011). These studies share the common view that the fundamental price of an asset (i.e. the cargo price) is given by the present value of the benefits stemming from the possession of the asset (i.e. the freight rate). In this instance, the model is specified in the following mathematical terms:

$$P_t = \frac{P_{t+n} + \sum_{i=1}^n f_i}{(1+r)^n} \quad (4.1)$$

Where:

$P_t$  is the price for a new dry bulk cargo at time  $t$ ;

$P_{t+n}$  is the future selling price after  $n$ -periods;

$f_i$  is the freight rate or the premium accrued to the owner of the cargo;

$r$  is the discount factor.

It is assumed that the price of a dry bulk vessel is given by all the future expected revenues generated by the vessel itself (namely, the freight rates), under the assumption of risk neutrality and no arbitrage. It is possible to rewrite Equation 4.1 with the conditional expectation operator which provides the fundamental asset price of a dry bulk vessel as:

$$P_t = \frac{\mathbb{E}[P_{t+n} + \sum_{i=1}^n f_i]}{(1+r)^n} \quad (4.2)$$

The term  $\{P_t - \mathbb{E}[P_{t+n}]\}/(1+r)^n$  converges to the fundamental price  $P^*$  and the remaining part of the equation becomes the discounted cash flow generated by the vessel:

$$P_t^* = \frac{\sum_{i=1}^n f_i}{(1+r)^n} \quad (4.3)$$

According to this specification, a speculative price is the situation in which the fundamental cargo price diverges from the underlying freight rate and thus is inflated by a bubble component such as:

$$P_t = P_t^* + B_{t+n} \quad (4.4)$$

Given this specification, the term  $B_{t+n}$  represents the speculative bubble component, or the speculative gain which the cargo owner expects to receive by reselling the asset at time  $t + n$ . If freight rates experience speculative periods, Equation (4.4) requires that the rational ship-owner, willing to invest in a brand new cargo, expects the speculative price to grow at a rate that equals the interest rate  $r$ . If this is the case and if  $B_t$  is strictly positive, speculative investors would invest and capitalise future profits: the rational ship-owners invest in an “overpriced” cargo since they believe that the future price increases will sufficiently compensate for today’s extra payment  $B_t$ . If the bubble component constitutes a large part of the price, then the expectation that it will increase at rate  $r$  means that investors expect price increases that are unrelated to changes in fundamentals. If enough investors have this expectation and buy shares, the stock price will indeed increase and complete a loop of a self-fulfilling prophecy. Since the fundamental value is not observed, assumptions have to be considered to characterize the time series properties of the fundamental price  $P_t^*$ .

This assumption is in contrast with the Efficient Market Theory (EMT): according to this theory, if prices fully reflect the information available to market participant then bubbles wouldn't exist as would be removed by arbitrageurs (Fama, 1970). However, a large debate has sparked between scholars to reconcile this view with the existence of speculative behaviours on capital markets. The first theory challenges that it is very difficult to have a fully informed investor as many are subject to self-confirmation biases (Taleb, 2008), over-confidence and money illusion (Akerlof & Shiller, 2009). A second theory states that in normal conditions it is difficult to arbitrage speculative bubbles away: because of trade restriction, short selling bans or just because the physical asset cannot be shorted directly then the temporary mispricing caused by speculation is not corrected. In addition, a third theory argues that it is possible that investors are aware that the price exceeds their fundamental value, however it is also possible that going against the market (higher-order mutual knowledge of all investors) makes the arbitrage opportunity riskier (Allen, Morris, and Postlewaite, 1993). This is the view expressed by Abreu and Brunnermeier (2003) with the term "*synchronization risk*": since a single entity (investor, trader or speculator) cannot reverse the market himself, there is the need to coordinate all rational market participants to arbitrage the bubble mispricing. However, in real world this is very unlikely to happen.

In order to test the speculative bubble theory, the literature provides different approach to tackle these issues. A first approach proposed by Flood and Garber (1980) points out that speculative bubbles generates within a rational asset pricing model and they represents the deviation of the asset price from the value derived from fundamentals (Garber & Flood, 1980). However, within this framework, statistical inference is not possible because of a biased estimation of parameters in a linear regression model. In fact, the regressor is biased by the growth rate and the parameter mainly relies on the most recent observation.

In order to overcome this caveat in this analysis, a convenient – and nevertheless empirically plausible – assumption is that freight rates follow a random walk with drift. If

the freight rates follow this type of process then the fundamental price (cost of buying a new vessel) should follow the same dynamics: the deterministic part (drift) shares commonality in the case of freight rates and new vessel prices in order to hinder arbitrage gains. As Diba and Grossman (1988) argue, in the absence of bubbles observed prices are equal to fundamental prices and are hence integrated of the same order as dividend. As suggested in Bhargava (1986), it is possible to verify the switch from stationary to explosive path by testing the parameter associated to the first lag of an AR(1) model.

Therefore, to preliminary test speculative behaviours, it is possible to specify the autoregressive model (AR(1))" as following:

$$Fr_t = \rho Fr_{t-1} + \varepsilon_t \quad (4.5)$$

Where  $Fr_t$  represents the level of Freight rates at time-t,  $Fr_{t-1}$  is the first lag and  $\varepsilon_t$  is the white noise component of the model with  $\mathbb{E}[\varepsilon] = 0$  and variance  $\mathbb{E}[\varepsilon^2] = \sigma^2$ . Following Bhargava (1986), it is now possible to test whether  $\rho$  assumes values larger than 1. The model is specified without the constant because the parameter was not found to be significant to preliminary tests. This result is in line with other studies applied on high frequency data (for a review see: (Homm & Breitung, 2010)).

Additionally, in order to further evaluate the presence of significant differences between the dry bulk speculative periods, the dataset is divided into three sub-samples: during, after speculative bubble and full sample (as stated in Section 4.2). Then, a stationarity test (augmented Dickey–Fuller test, ADF) is performed over the three periods under scrutiny. The basic idea of the test is to assess whether or not the three samples experience different degrees of persistency, autocorrelation and changes in memory of the time series.

**Table 4.3** ADF test of bubble, post bubble and full sample datasets.

<i>ADF Test</i>	<i>During</i>	<i>After</i>	<i>Full Sample</i>
Tau	-4.823	-1.698	-2.224
Asymp. P-Value	1.73E-06	0.085	0.025

The ADF test confirms that there has been a substantial change in the parameter estimated in the model and in particular the results of Table 4.3 show that during the peak to trough phase the hypothesis of stationarity is not confirmed (with different confidence levels). The coefficient tau has an associated asymptotic p-value that rejects the hypothesis of stationarity whereas in the “*full sample*” and “*after*” sample it is not possible to draw the same conclusions. Finally, in the analysis it was found that the “*during*” sample has registered the highest level of non-stationarity in the time series. Following the mainstream literature, this result constitutes a first evidence of speculative cycle is present in dry bulk freight rates.

### **4.3 Freight rates speculative bubble testing: an extension based on global factor risk modelling**

Section 4.3 corroborates the results obtained by the ADF test by applying a cointegration test. In this case, the study examines whether there is a long-term relationship between cargo price and freight rates in order to verify the existence of speculation in the dry bulk industry. According to the relationship depicted in Equation (4.4), if the test outcome confirms no cointegration between freight rates and cargo prices it means that the bubble component is priced in the asset price of a new built vessel. In fact, the cointegration analysis tests for long-term relationship among the variables and shows whether two variables share a common stochastic trend: in econometric terms, we expect that if the speculative bubble affects prices, it disrupts the long-term relationship between fundamental and underlying prices (Engle & Granger, 1987).



However, a shift in the level of the Data Generating Process (DGP) must be taken into account when testing for a unit root, because this effect might create biased estimations of the parameter of interest. In fact, it has been argued that if a speculative bubble exists, the variance of prices is greater than the variance of fundamental prices (LeRoy, 1989; Shiller & Beltratti, 1992). Originally conceived as a test of the rational market hypothesis, these speculative tests aim to verify whether the observable asset price is the expectation of the unobservable fundamental price, conditional on the available information. Hence, the observable asset price constitutes an optimal forecast for  $f_t$ . It follows that, under the null hypothesis of no bubbles, the variance of the fundamental price sets an upper bound to the variability of the actual asset price, thus the variance bounds tests interpret an excess volatility as an indication for price bubbles. However, West (1988) points out that excess volatility may also be caused by variations in expected returns, therefore the volatility tests suffer from a small sample bias. In order to overcome this caveat, it is useful to implement a global factor assessment which enables a direct control of freight and cargo price covariance changes, thus providing the unique opportunity to slice and dice the main risk components that contribute to the fluctuations of freight rates. Thanks to this flexible approach, the factor estimations derive the variance/covariance matrix of the two variables under scrutiny (freight rates vs cargo prices) and finally these estimations are used to test freight rates and cargo prices cointegration (Johansen, 1991).

For this purpose, an extensive dataset of four major global indexes is collected: Global Equity Price Index (MSCI World), Global Bond Price Index (JP Morgan Global Bond Index), Global Commodity Price Index (S&P - SPGSCI), Trade Weighted U.S. Dollar Index (USDTW). The time series spans from Jan-1990 to Jul-2015. This comprehensive modelling takes steps from the global risk modelling developed by MSCI Barra (MSCI Barra, 2007) and assumes that these four key drivers of global economic activity can comprehensively describe the functioning of the Dry Cargo Selling Prices and Baltic Dry Freight Index (Stopford, 2007).

According to this specification, the main trends between global factors and freight rates, coefficient estimations and residuals are derived from a global multi-factors model (Ng, et al., 1992). The information obtained are then used to estimate variance, covariance and standard errors for the speculative testing between the Baltic Dry Index (*BDI*) and Cargo Prices. The global multi-factor regression model can be analytically derived as following:

$$\text{Cargo Price}_t = \alpha_t + \beta_1 \text{JPMGBI}_t + \beta_2 \text{SPGSCI}_t + \beta_3 \text{MSCI}_t + \beta_4 \text{USDTW}_t + \varepsilon_t \quad (4.6)$$

$$\text{BDI}_t = \alpha_t + \beta_1 \text{JPMGBI}_t + \beta_2 \text{SPGSCI}_t + \beta_3 \text{MSCI}_t + \beta_4 \text{USDTW}_t + \varepsilon_t \quad (4.7)$$

The results of multi-factor regressions are listed in Table 4.4.

**Table 4.4** Global multi-factor regression: Cargo Price and Freight Rates.

<i>PRICE</i>	<i>Coeff.</i>	<i>Std. Error</i>	<i>Pr(&gt; t )</i>		<i>FREIGHT</i>	<i>Coeff.</i>	<i>Std. Error</i>	<i>Pr(&gt; t )</i>
JPMGBI	-3.353	0.625	0.000		JPMGBI	-1.469	1.933	0.249
SPGSCI	0.007	0.185	0.969		SPGSCI	1.010	0.571	0.080
MSCI	0.438	0.250	0.063		MSCI	0.026	0.775	0.674
USDTW	-1.590	0.964	0.083		USDTW	-3.930	2.982	0.091
R.S.Error	0.091	R <sup>2</sup>	0.55		R.S. Error	0.181	R <sup>2</sup>	0.40

Before discussing the main result of this analysis, some important outcome of the global multi-factor modelling are emphasised in Table 4.4; first, it is interesting to notice that both cargo prices and freight rates are negatively affected by the performance of global bonds. This result is in line with the background provided by previous sections: an increase in borrowing costs leads to a better performance for the index itself while it restricts the access to credit it reduces the cost of cargoes<sup>1</sup>. Furthermore, it is interesting to notice that

<sup>1</sup> Dry bulk cargoes are long term investment often financed by debt (Wright, 2016)

the commodity behaviour has no significant impact on the cargo price performance, whereas it has a large and significant impact on the level of freight rates.

The vector containing beta coefficients ( $\beta$ ) derived in the previous estimations is now used to derive the estimated variance-covariance matrix for the Dry Bulk Freight Index (Zivot, 2015):

$$\hat{\sigma} = \beta \Omega \beta' + D \quad (4.8)$$

Where:

$\hat{\sigma}$  is the variance matrix estimated for cargo prices / freight rates;

$\beta$  is the vector containing the multi-factor regression coefficient for cargo prices / freight rates;

$\Omega$  is the factors covariance matrix;

$D$  is a diagonal matrix containing the residual variance from the regression.

Applying this methodology to derive the variance and covariance for the dry bulk and the cargo prices allows to: first, understand the main sources of systematic risk generated from shifts in underlying global factors. Secondly, equalise the specific marginal risk contribution arising in the two instances under examinations. Thirdly, mitigate for the unexpected short-term changes in the underlying markets (cargoes and freight) thus reducing structural variations in the level of volatility.

As suggested in Maillard et al. (2009), it is possible to derive and equalise the marginal risk contributions for each factor included in our analysis as following (Maillard, et al., 2009):

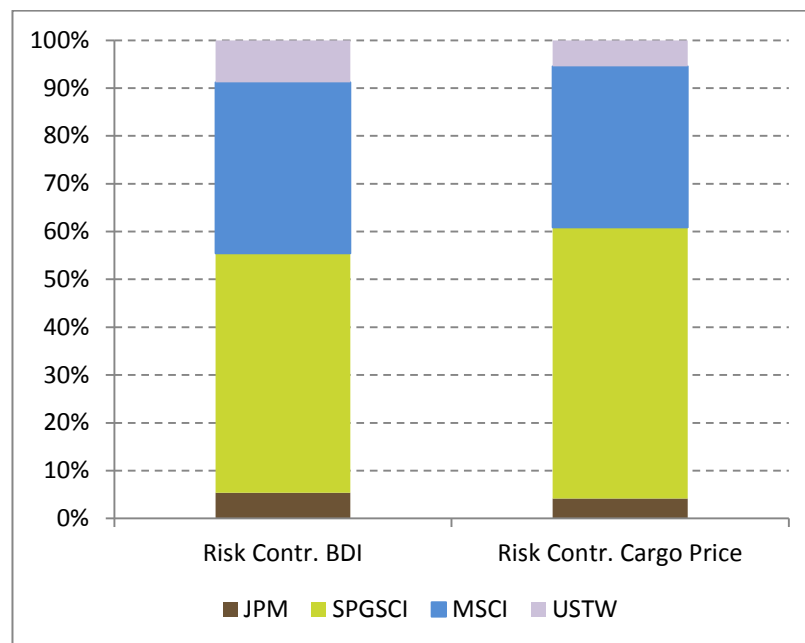
$$\sigma_{Index} = \frac{\partial \sigma_{factor}}{\partial w} \quad (4.9)$$

where:

$\sigma$  is the standard deviation and  $w$  is the weight derived by the estimations of beta from the multi-factor regression.

The marginal risk contributions for the BDI and the Dry Cargo Price indices are the first derivatives of its variability in respect to its weight. A visualisation of the marginal risk contributions for BDI and Cargo Price is depicted in Figure 4.4.

**Figure 4.4** Marginal risk contributions: Baltic Dry Index and Cargo Price Index.



As Figure 4.4 shows, it is possible to attribute to each factor similar contributions in the overall variability: although there are some small differences, the factors contribute with the same proportion to the final total variations in both BDI and Cargo Prices. Additionally, it is noted that the main risk contributions are provided by Commodity Prices and Equity Market exposures: this is mainly due to a larger variability in stock prices and also to the commodity prices roller coaster behaviour over the past 10 years.

Having estimated the variance covariance matrix for both Freight Rates and Cargo Prices, it is now possible to finally estimate the cointegration parameters by using the general estimation framework provided in Johansen (1995); in doing so, the model combines the global multi-factor model results with the testing of cointegration parameters for the two

variables under scrutiny, without losing any important information due to volatility spikes and regime switches in the variable under scrutiny. Following Engle and Granger (1987), Dry Cargo Prices and Freight Rates time series are tested for cointegration at the 5% level of significance. The result of this test shows that the null hypothesis of cointegration between cargo prices and freight rates cannot be rejected, thus confirming a difference between the asset price and the economic fundamentals (Table 4.5).

**Table 4.5** Bivariate cointegration results: Cargo Price vs Baltic Dry Index.

<i>Cointegrating Regression</i>				
<i>Cargo Price</i>	<i>Coef.</i>	<i>Std. Error</i>	<i>T-ratio</i>	<i>P-Val.</i>
BDI	0.00069	0.0353	0.0195	0.98
Akaike Criterion	165.62	Durbin-Watson		1.72

As Diba and Grossman (1988) argue, if the price of the asset depends only on future revenues that self generates (i.e. dividends, rents, freight rates) and if there are no rational speculative bubbles, then, if the revenues are stationary, the same should be true for the price of the asset. In view of this result, the cointegration test should confirm a significant cointegration test between freight rates and cargo price: in this light we can confirm that speculation affected the dry bulk market between 2005 and 2010.

**Table 4.6** Cointegration results.

<b>Cointegration tests</b>					
<i>Rank</i>	<i>Eigenvalue</i>	<i>Trace Test</i>	<i>P-Val</i>	<i>Lmax Test</i>	<i>P-Val</i>
0	0.185	24.882	0.001	17.597	0.003
1	0.081	7.2851	0.007	7.285	0.009
<b>Corrected for sample size</b>			<b>Beta (cointegrating vectors)</b>		
<i>Rank</i>	<i>Trace Test</i>	<i>P-value</i>	<i>CARGO</i>	47.564	-25.512
0	24.882	0.001	<i>BDI</i>	-33.269	-7.656
1	7.2851	0.008			

Table 4.6 provides the test results for both ranks of coefficient matrix: the Eigenvalue test and Rank Trace test. These results support the findings of the previous section however it is further emphasised that the two Indexes are not cointegrated for the long run relationship test (see Trace Test, Table 4.5). the Cargo Index and BDI time series show no evidence of cointegration, thus the initial hypothesis is confirmed: freight rates and cargo prices do not share a common behaviour and therefore a speculative bubble is plausible.

#### 4.4 Back-testing

In order to back-test the estimations used to derive the covariance matrix, a rolling window analysis of 48 periods is applied to Equation (4.7). The estimations generated by this model provide three important results: first, the sensitivity of coefficients; secondly, time varying patterns; and thirdly, a comparison between the full sample estimations and the rolling regression estimation distributions. According to these goals, the global multi-factor model is re-written as following:

$$BDI_{t:t-48} = \alpha_{t:t-48} + \beta_1 JPMGBI_{t:t-48} + \beta_2 SPGSCI_{t:t-48} + \beta_3 MSCI_{t:t-48} + \beta_4 USDTW_{t:t-48} + \varepsilon_{t:t-48} \quad (4.10)$$

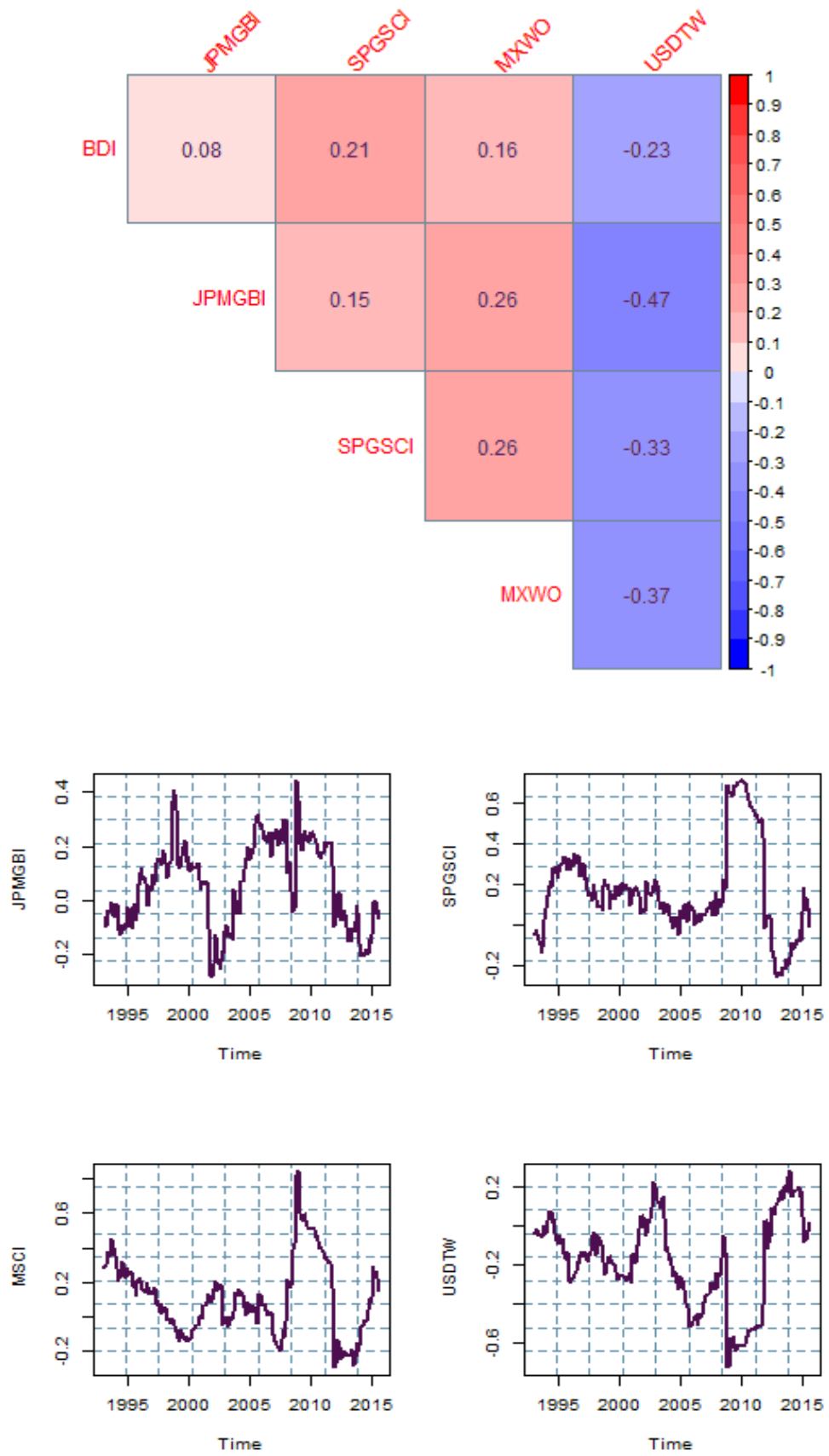
Where the term  $(t:t-48)$  represents the rolling window applied in our testing. This model specification assumes that it is possible to explain the general level of freight rates in the dry bulk industry as these four factors should represent accurately the state of the global economic activity. Given this assumption, multifactor regression is run first on a dynamic rolling window of 48 months and secondly on the static full sample selection. This type of analysis identifies if any particular factor change has happened in the period spanning between 1993 and 2015 and it is particularly useful to evaluate any unusual pattern through the speculative period. Figure 4.5 depicts a preliminary analysis of correlations between dry bulk freight index and global factors: what appears immediately interesting is the behaviour of correlation between 2005 and 2010. While some of these correlation

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coefficients suddenly drop (USDTW and JPMGBI), others spike and it is particularly interesting that the Commodity Global Index (SPGSCI) leaps from a low correlation of 0.2 in 2006 to 0.8 in 2008.

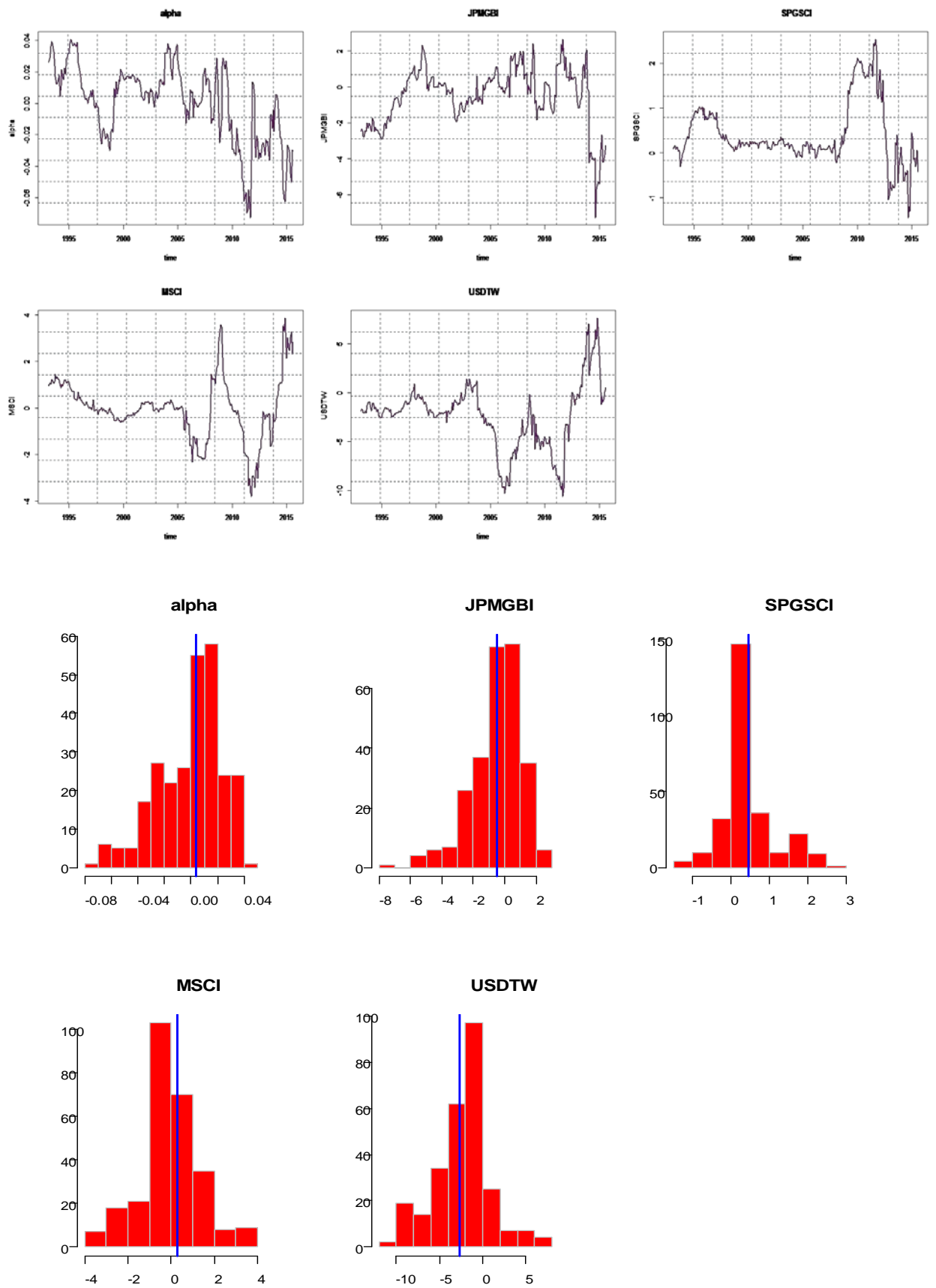
This large correlation change (0.6) and the steepening of the correlation coefficient are further enlightened in the multivariate modelling. Figure 4.6 shows the results of the rolling window multi-factor regression model against the Baltic Dry Index. On the left hand side, it shows the coefficient behaviours whereas on the right hand side it presents the graphical distribution for each coefficient and compares it to the static regression coefficient (blue vertical line) used before to estimate the covariance matrix.

**Figure 4.5** Static and rolling correlation: Dry Bulk Freight Index vs Global Factors.





**Figure 4.6** Multi-Variate Regression: Dry Bulk Freight index vs Global Factors.



Based on these results, it is possible to conclude that freight rates dynamics were particularly under pressure between 2005 and 2010. In particular, it is verified that a consistent time-varying and regime switching effect took place: to some degree, the model is well balanced before the boom and bust period and an important component is linked to the global performance of bonds (JPGBI). However, these relationships weaken between 2005 and early 2011, suggesting that major forces were driving the level of freight rates apart from the debt market trends. As Figure 4.6 shows, equities (MSCI) and commodities (SPGSCI) become the main factors driving freight rates patterns and this suggests compelling patterns in directionality for the dry bulk market: equity oriented risk factors explain a more aggressive and rather volatile market place, where sudden spikes and momentum changes might turn the level of freight rates from booms to busts. Ultimately, the speculative period has created a more nervous market, vulnerable to reversals and stiffer shock absorption.

On the right hand side of Figure 4.6, the distribution of the parameters for the global multi-factor modelling is shown; the blue vertical line indicates the parameter estimated by the full sample static model. Although dislocations in the coefficient estimations and a time varying effect are present, Figure 4.6 shows that the static full sample estimations provide a good broad picture of the underlying forces driving freight rates changes. Empirical evidence shows that most of the parameters estimated from the static model are centred in the dynamic parameter estimations. Therefore, it is possible to conclude that the static estimation can be used to derive a variance and covariance matrix for the two main variables under investigation.

## 4.5 Conclusion

The boom and bust cycle experienced in dry bulk industry between 2005 and 2010 was the background of Chapter 4. Given this context, the main goal was to prove the occurrence of speculation in the dry bulk industry by testing the long term relationship between the asset price (i.e. Dry Bulk Cargo price) and its fundamental (i.e. the Baltic Dry Index). This objective was achieved by implementing a global multi-factor model which estimated the variance-covariance matrix to be tested for cointegration relationship. The global multi-factor model accounted for the main drivers of global economic growth: Equity, Bond, Commodity and Trade. The estimations were used to derive the variance covariance matrix and finalise a cointegration test following Johansen (1995).

The main results of Chapter 4 are summarised as following: the Dry Bulk Cargo industry has experienced a period of large fluctuations; the cointegration test has shown that this boom and bust cycle in freight rates was driven by speculation; there has been a sudden shift in the main variables explaining the behaviour of dry bulk freight rates and among those the predominant is commodity prices.

It would be useful to extend in future works this framework from static to dynamic analysis in order to detect ex-ante the presence of speculative bubbles. However, the problem with this specification is that given the structure of financial time series, auto-correlated and showing clustering of periods characterised by high degrees of volatility followed by low volatility periods it could lead to bias estimations of the model coefficients. If factor returns were uncorrelated across time, the methodology used in this chapter is sufficient for modelling Freight and Cargo prices. However, although the assumption of serial independence for returns is consistent for longer horizons, this doesn't hold for short term asset returns. Over short time frames, market microstructure tends to develop sort of "*momentum*" relationships that induce autocorrelation in the returns. In order to overcome, the financial literature have developed models that reduce these drawbacks, among others it is important to cite GARCH/ARCH models (Engle, 1995), Newey West

Methodology to estimate robustly the covariance matrix in presence of serial autocorrelation (Newey & West, 1987) exponential weighted moving average to correct for long time series memory (Lucas & Saccucci, 1990).

In fact, it is possible that these effects are the final outcome of the speculative cycle in the commodity market described in Chapter 2 and Chapter 3. Raw materials and bulk commodities such as grains, coal and iron ore, are shipped mainly by ocean vessels and they constitute (in terms of weight) the largest amount of international trade (Hummels, 2007). Given these results, Chapter 5 will assess whether the speculative cycle was caused by a speculative spillover from the commodity market.

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## Chapter 5 Boom and bust cycles: an empirical of market spillovers in wheat prices and dry bulk freight rates

### 5.1 Introduction

Speculation plays a pivotal role against financial stability by threatening efficient pricing, investment levels and counterparty risk. Due to an increasing level of financialisation, commodity markets are exposed to boom and bust cycles and speculative investments (Tank & Xiong, 2010). For instance, between 2007 and 2010, the global agricultural commodity market experienced high levels of price fluctuation and volatility (FAO, 2009). In particular, starting from 110 points in 2006, wheat price index peaked at over 230 points in June 2008 and nearly halved to 120 points in December 2008. Along with investment decisions, level of inventories and policies, the boom and bust cycle in wheat price was caused by many factors and one of the most debated is the presence of speculators, which had a major impact on commodity prices and exacerbated the level of related volatility (Gutierrez, 2013). Esposti and Listorti (2013) emphasise that the roller coaster behaviour experienced in the two markets was caused by over-expectations, exuberance and speculative investments. As a result, the extreme price swings and volatility in wheat prices raised concerns regarding to food security and commodity merchandising (FAO, 2011).

Wheat is a dry clean commodity and is shipped all around the globe by bulk carriers (Hummels, et al., 2009). The leading guide to the cost of wheat transport by dry bulk carriers is the North West Pacific route which links the main producers of wheat in America (US and Canada) to the Far East regions of the world. This route has an

outstanding importance for international trade and provides vital statistic for the calculations of the Baltic Dry Index (BDI). The North West Pacific (NWP) freight rate has observed a similar cycle to the one experienced by wheat prices: between January 2006 and October 2007, the index increased by more than 400%, from 2,081 points to 10,656 points and then collapsed sharply to 715 points in December 2008.

Dry bulk rate market is complex, and participants, including ship owners, operators and charterers, face significant price risk and volatility (Stopford, 2007). The characteristics of the freight rate formation and commodities pricing raise the question of whether or not speculative effects can spread from one market to another causing irrational investments and transmitting over-expectations. Indeed, dry bulk freight rates and transportation costs play an outstanding role in agricultural commodity pricing and in particular to farmers and producer mark-ups (Kilkenny, 1998). According to the agricultural economic literature, the amount paid to farmers is the difference between wheat prices determined in major grain markets minus handling costs and transportation costs (Smith, 1992). As a matter of fact, the speculative surge in wheat prices enlarged mark-up and margins for farmers and increased their propensity to afford higher freight rates (Henderson, et al., 2011).

Despite the extensive literature on the cause of the peak to trough phase in commodity markets and freight rates, relative importance has been focussed in understanding how speculative behaviours can spread across markets and become contagious. Irrational behaviours in asset pricing can be contagious and can spread across different markets. Similar patterns have been observed between oil and commodity markets (Du et al., 2011), warrant and stock market (Liu et al., 2011), stock prices and real estate (Malpezzi and Watcher, 2005) and have been proved to be contagious speculation amongst different stocks in one market (Huberman and Regev, 2001).

The aim of Chapter 5 is to evaluate whether or not speculative effects can be transmitted from commodity markets to freight rates or vice versa; in particular, the analysis seeks to

evaluate whether freight rates are influenced by the widening of wheat mark-ups over expectations in wheat market. Based on the analysis of data (2000-2011) of weekly time series of wheat price (US Wheat) and freight rate (North West Pacific Route), we will implement a multivariate Cointegration Test and Vector Error Correcting Model that comprehensively analyses the speculative effects in both markets under scrutiny.

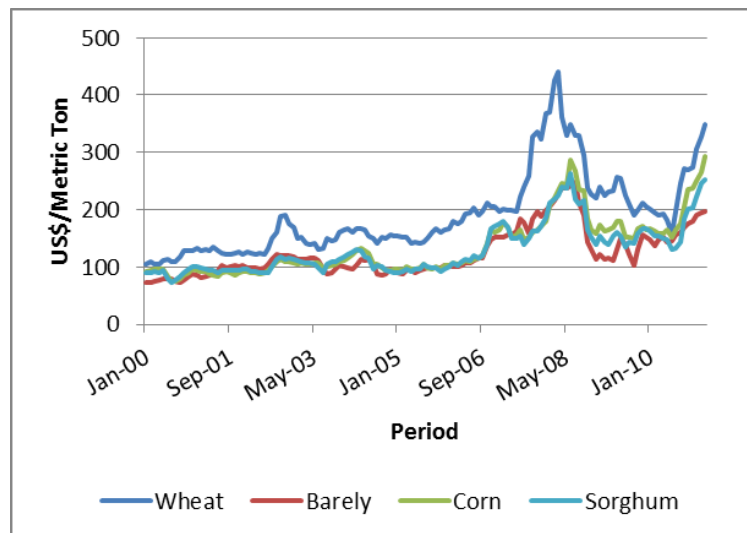
The research presented in Chapter 5 argues that first, an extreme level of liquidity in commodity markets, provided by institutional investors, can cause a steep increase in wheat price. Second, the speculation in the wheat market can threaten the stability of freight rates and therefore causes cascading effects in such a way that it biases not only the efficient pricing but leads to a distortion in investment and consumption decisions. Third, the increasing financialization of commodity markets widens the co-movements with freight rates.

The Chapter follows a progressive analysis where first, it is shown how speculative shocks in commodity pricing are transmitted to freight rates. Secondly, it implements a Vector Error Correcting (VEC) model and demonstrates that wheat prices have a positive impact on the level of freight rates. In doing so, it will be shown how speculation in commodity markets causes pricing bias in dry bulk freight rates. Given this background Chapter 5 is organised as following: Section 5.2 provides a rational background to this study by representing the main characteristics of wheat and freight rate markets; Section 5.3 describes the data and methodology applied; Section 5.4 presents the data analysis and delivers a critical discussion of the main findings; Section 5.6 dives into the relationship between freight rates and commodity price by implementing a dynamic model (VEC Model); finally, Section 5.6 concludes the work by drawing important recommendations that can be useful to both ship-owners and commodity practitioners as well as policy makers.

## 5.2 Commodity and freight rate markets

The European Commission on Agricultural and Rural Development (2011) asserts that, for most agricultural commodities between 2007 and 2010, price volatility has been conspicuously higher than during any other period since 1960 (Pfuderer and del Castillo, 2008). In particular, between 2007 and 2010 the world experienced fluctuations in food prices, and agricultural commodity prices in particular rose sharply between 2006 and 2007, with a noteworthy increase from January to March 2008 (FAO, 2009). However, during the second half of 2008 prices plunged and then receded significantly from their peak in late 2007, thereby creating the peak-to-trough pattern depicted in Figure 5.1.

**Figure 5.1** Grain price time series. Data Source: FAO database.

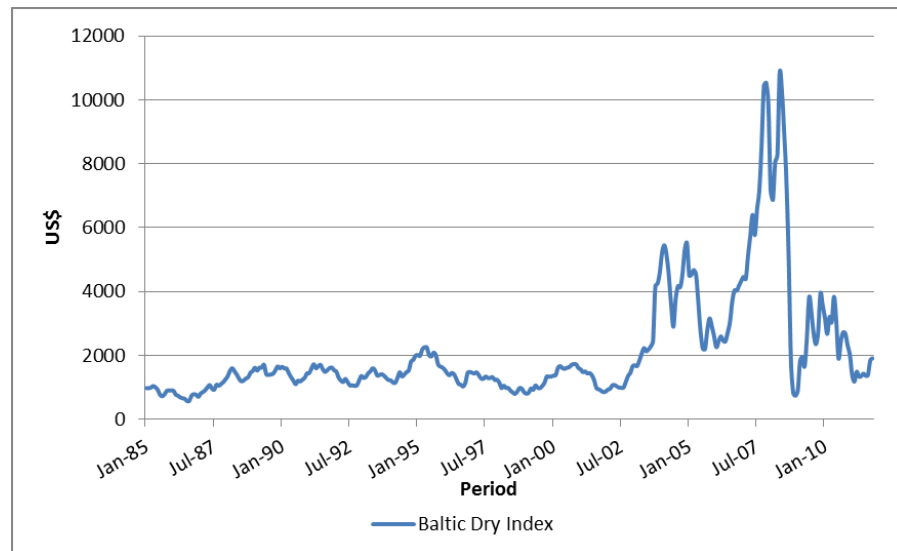


Having observed a similar trend in commodity markets, data shows the same “roller coaster” behaviour of freight rates, with sharp growth and steep declines in conjunction with high volatility, for instance, between 2007 and late 2008 (Lu et al., 2008). The fluctuations in dry bulk freight rates have been particularly conspicuous between 2005 and 2010. As Figure 5.2 depicts, in this period of time the dry bulk freight index witnessed a peak to trough phase that had never been experienced before. The volatility was without precedent and the market was running very fast (Duru, 2013): as shown in Chapter 4, the peak to trough phase in the dry bulk freight rate market between 2005 and 2010 was



characterised by a speculative phase that drove the price of freight away from the price of fundamentals.

**Figure 5.2** The Baltic Dry Index. Data Source: Thompson Reuters database.



The relevance of interrelations between commodity and freight rates prompts the analysis of the relationships across these markets and, in particular to examine how increases in commodity prices can impact on freight routes and vice-versa. Furthermore, it is in the aim of this Chapter to show how micro-shocks affecting agricultural commodity markets might influence route pricing and ship owner investment decisions thus triggering speculative effects.

Against this background, through econometric analysis, the next section investigates whether agricultural commodity and dry bulk freight rates share a common trend. In addition, it studies the causality relationships between crude oil prices, wheat prices and dry bulk freight rates and subsequently develops a model to assess how price shocks spillover from one market to the other. Chapter 5 provides an empirical analysis of grain price and dry bulk freight rates time series in an examination of the North West Pacific Route (US to Japan) and US wheat prices. In doing so, the study carries out a stationarity test and a cointegration test in order to identify the long-run relationships between the time series. It also conducts a causality test to clarify the relationships occurring between our

variables under scrutiny. Finally, it assesses whether grain prices affect freight rates through a multivariate econometric model known as the Vector Error Correcting Model (VECM) (Granger, 1969, 1981; Engle and Granger, 1987; Johansen, 1991).

### 1.3 Freight rates and commodity prices

The empirical analysis focuses on the interactions between wheat price and freight rates. It uses weekly spot freight rates data from 07/01/2000 to 24/06/2011 and weekly wheat prices for US no. 2 Hard Winter Wheat from 07/01/2000 to 24/06/2011. The use of weekly data describes comprehensively the two variables and reduces much of the volatility originated by daily observations (liquidity constraints in these markets can create abnormal returns when prices are examined on daily basis). On the other hand, by using a sample from 2000 it is possible to partially offset the large fluctuations generated in the boom and bust period (2006 to 2011). The selection of the route has been dictated by the necessity to examine a route that epitomizes the behaviour of the markets; in our case Japan is the main importer of US wheat (12% share) along the considered Pacific US North West-Japan route. The dataset collected comprises 599 observations for each variable under scrutiny. The units in the case of wheat time series are dollars per metric ton, whereas for freight rate, the figure is dollars per day (Figure 5.3).

**Figure 5.3** Freight and wheat time series. Data Source: Thompson Reuters and FAO database.

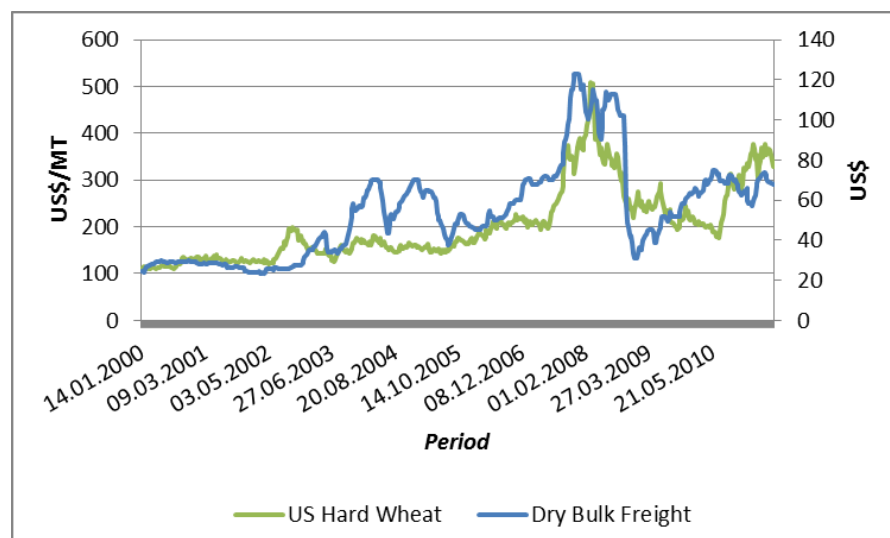


Figure 5.3 shows how the markets are related and how they are characterized by peaks and trough phases with high volatility, especially between 2005 and 2010. The main assumption is that if the two time series (freight rate and wheat price) are integrated of the same order, that is, if they become stationary after differentiating  $n$ -times, we can examine their long-run relationships through cointegration analysis (Granger and Newbold, 1974). The concept of cointegration is important here because it allows the demonstrations of how non-stationary stochastic time series can be employed to construct models such that the results are both statistically unbiased and economically significant (Granger and Newbold, 1974; Granger, 1981; Granger and Weiss, 1983). Cointegration analysis has been used by various researchers to assess the dynamic long-run relationships between commodity prices (Bekiros and Diks, 2008; Harri *et al.*, 2008; Lardic and Mignon, 2008; Nazlioglu and Soytas, 2011; Golec *et al.*, 2012). In this context, of particular interest is the work of Natalenov *et al.* (2011) in which they use cointegration methodology to investigate parallel movements between crude oil and agricultural commodities (cocoa, sugar, corn, soybeans, wheat, and rice) and find strong linkages across these markets.

### **(Non-)Stationarity and Cointegration Tests**

The system of hypothesis ( $A$  and  $B$ ) on the parameters of interest is tested to evaluate the stationarity of the times series:

$$A. \begin{cases} \mathcal{H}_0: \gamma = 0 \\ \mathcal{H}_1: \gamma < 0 \end{cases} \qquad B. \begin{cases} \mathcal{H}_0: \varphi = 0 \\ \mathcal{H}_1: \varphi < 0 \end{cases}$$

$\mathcal{H}_0$  is rejected if the critical values are larger than the t-statistic and the time series are stationary. On the other hand, if the null hypothesis is not rejected, the case where  $\varphi = 0$  is obtained: the US wheat and freight rate time series have a unit root, i.e. they are not stationary. Following the Augmented Dickey Fuller (ADF) framework (Fuller, 1976; Fuller and Dickey, 1979), the vector containing the observation for US Hard Wheat,  $x$ , and the

vector containing the observations Freight Rates,  $y$ , can be written as an autoregressive polynomial:

$$\Delta x_t = \gamma x_{t-1} + \sum_{j=1}^{r-1} \beta_j \Delta x_{t-j} + \varepsilon_t \quad (5.1)$$

$$\Delta y_t = \varphi y_{t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta y_{t-j} + u_t \quad (5.2)$$

where  $\gamma$  and  $\varphi$  represent the parameters of interest.  $\beta$  and  $\alpha$  are respectively, the parameters associated with the first differences of wheat and the first differences of freight,  $r$  and  $p$  represent the number of lags included in the equations, and  $\varepsilon$  and  $u$  are vectors containing the residuals of the models which are assumed to be normally distributed with zero mean and constant variance. The number lag included in the model is selected according to the following criteria: AIC, Hannan-Quinn Criteria and absence of serial correlation in the residuals. Therefore, the  $t$  statistic of the regression from Equations 5.1 and 5.2 are used to fully evaluate the hypothesis and the results of ADF test and the critical values are presented in Table 5.1.

**Table 5.1** ADF test estimations.

<i>ADF Test on Level Variables: Freight and US Wheat</i>	
<i>ADF Test</i>	<i>t-stat</i>
Freight	-2.08
USwheat	-2.03
Asymptotic Critical Values (5%)	-3.41
<i>ADF Test on First Difference Variables: Freight Rates and US Wheat (First Differences)</i>	
<i>ADF Test</i>	<i>t-stat</i>
Freight_d1	-7.69
USwheat_d1	-8.28
Asymptotic Critical Values (5%)	-2.86

From the values listed in Table 5.1, it is concluded that the wheat and freight variables are non-stationary in levels; therefore, it is not possible to reject the null hypothesis of non-stationarity and the process has a unit root (t-stat approximately -2 against a critical value of -3.41). Additionally, by differentiating the time series, it is reached the conclusion that wheat and dry bulk freight rates have unit root and this can be considered as an I(1) process.

#### 5.4 Dynamic analysis

Since the time series are integrated of order (1), there is the need to identify the dynamic relationships between freight rate and wheat price. In order to examine the dynamics between the two prices under consideration, in this Section it is implement a cointegration methodology to verify if wheat price and freight rate share a common trend. The cointegration analysis allows to ascertain whether wheat price and freight rate maintain a long-run equilibrium. The two variables are cointegrated if: (I) they are integrated of the same order or: (II) there is a stationary linear combination of the two variables. The assumption in this instance is that wheat price and freight rate are expected to move together; in other words, the simulation of the explanatory variable -  $x_t$  (US hard wheat) should reproduce the major properties of the response variable -  $y_t$  (Dry Bulk Freight Rate). Given the two random variables,  $x_t$ , US Hard Wheat, and  $y_t$ , Dry Bulk Freight Rate, Integrated of order 1 ( [I(1)] ), through an autoregressive model, we can denote the system as:

$$\begin{cases} x_t = \sum_{i=1}^p \beta_{1i} x_{t-i} + \sum_{i=1}^p \gamma_{1i} y_{t-i} + \varepsilon_{1t} \\ y_t = \sum_{i=1}^p \beta_{2i} x_{t-i} + \sum_{i=1}^p \gamma_{2i} y_{t-i} + \varepsilon_{2t} \end{cases} \quad (5.3)$$

where  $\varepsilon_{1t}$  and  $\varepsilon_{2t}$  are the residuals identically and independently distributed following a  $N \sim (0 ; \sigma^2)$ . We can now represent it as an I(0) process such as:

$$\begin{cases} \Delta x_t = \alpha_1(y_{t-1} - \theta x_{t-1}) \sum_{i=1}^{p-1} \beta_{1i} \Delta x_{t-i} + \sum_{i=1}^{p-1} \gamma_{1i} \Delta y_{t-i} + \varepsilon_{1t} \\ \Delta y_t = \alpha_2(y_{t-1} - \theta x_{t-1}) \sum_{i=1}^{p-1} \beta_{2i} \Delta x_{t-i} + \sum_{i=1}^{p-1} \gamma_{2i} \Delta y_{t-i} + \varepsilon_{2t} \end{cases} \quad (5.4)$$

Following Johansen (1991, 1995) who employed a VAR specification to test the rank of coefficient matrix, we specify a vector ( $p \times 1$ ) of US Wheat Price and freight rate variables =  $(x, y)'$ , as follows:

$$\mathbf{z}_t = \boldsymbol{\mu} + \sum_{i=1}^p \mathbf{A}_i \mathbf{z}_{t-i} + \boldsymbol{\varepsilon}_t \quad (5.5)$$

where  $\boldsymbol{\mu}$  is a vector ( $n \times 1$ ) containing the deterministic components,  $\mathbf{A}_i$  is the parameter matrix, and  $\boldsymbol{\varepsilon}_t$  is a vector ( $n \times 1$ ) of innovations. Equation 3 can now be written as:

$$\Delta \mathbf{z}_t = \boldsymbol{\mu} + \boldsymbol{\Pi} \mathbf{z}_{t-1} + \sum_{i=1}^{p-1} \mathbf{A}_i \Delta \mathbf{z}_{t-i} + \boldsymbol{\varepsilon}_t \quad (5.6)$$

In Table 4.2 are provided the results of two likelihood ratio tests for the significance of the correlations and the rank of coefficient matrix: the Eigenvalue test and Rank Trace test (Hjalmarsson and Österholm 2007; Johansen 1995). The tests show that the analysed time series are integrated of order one following a common trend; therefore, it is confirmed the initial hypothesis that freight rate and wheat price share a common behaviour and the two markets are linked in their price patterns.

**Table 5.2** Eigenvalue test

<i>Rank</i>	<i>Eigenvalue</i>	<i>Trace test</i>	<i>p-value</i>	<i>LMax test</i>	<i>p-value</i>
0	0.027464	18.854	0.01	16.32	0.02
1	0.004317	2.5352	0.11	2.54	0.11

**Table 5.3** Rank trace test

<i>Rank Trace</i>	<i>test</i>	<i>p-value</i>
0	18.85	0.01
1	2.54	0.11

In the next section, the causality between price time series and the long-run behaviour among them is tested in order to curtail and hedge the various risks embedded in the wheat and freight rate markets.

## 5.5 Back-testing the main findings: causality test and Vector Error Correction model

Fluctuations in operating and voyage costs in the shipping industry are mainly related to bunker costs (Stopford 2007). Due to recent large fluctuations in crude oil markets, the shipping industry has struggled to find new tools to hedge this variability (Alizadeh *et al.*, 2004). A study conducted by UNCTAD (2010) confirms this observation by testing that oil price changes impact on maritime freight rates (containers as well as bulk commodities); it is possible therefore to observe that freight rates are indeed sensitive to oil price movements, in particular in the dry bulk cargo (iron ore) segment of the market.

In this part of the research, it is implemented a Granger causality test (Granger 1969; Saghaian 2010) to account for instantaneous causality because the financialisation of the commodity market and shipping markets market can cause an increase in the transmission of shocks between these two variables under scrutiny. Specifically for this aim the a priori exogeneity hypothesis of oil price is relaxed. The results of instantaneous causality are listed in Table 5.4.

Table 5.4 Granger causality

<b>Test for Granger Causality</b>		
<i>Oil Granger cause Freight</i>	<i>Test stat.</i>	<i>P Value</i>
<b>H0: “Oil” do not Granger cause “Freight”</b>	3.1763	0.0077
<b>H0: No instantaneous causality between “Oil” and “Freight”</b>	10.8233	0.001
<i>Oil Granger cause Wheat</i>	<i>Test stat.</i>	<i>P Value</i>
<b>H0: “Oil” do not Granger cause “US wheat”</b>	3.6912	0.0027
<b>H0: No instantaneous causality between “Oil” and “US wheat”</b>	0.0724	0.7878

Results presented in Table 5.4 conclude that the null hypothesis is rejected because Oil Price does not Granger cause the prices of freight and wheat. There is an instantaneous causality between oil price and freight rate whereas the same causality is not present in the case of oil and wheat. Given these results, it is now possible to model dry bulk freight and wheat market behaviour by using a bivariate Vector Error Correction Model (VECM). The choice of model is dictated by the fact that in multivariate statistical analysis both variables are treated as endogenous and thus it is possible to study both short and long-run interdependencies across markets and the consequent adjustments to shocks (Engle and Granger, 1987). The Vector Error Correlation Model (VECM) is commonly used in commodities pricing (Johansen, 1995; Zhang *et al.*, 2010; Gambacorta, 2011; Mutuc *et al.*, 2011). This dynamic model analyses the economic relationships among freight rate, wheat price and oil market under both long-run and short-run periods.

The VECM method is established following the works by Maysami and Koh (2000) in order to estimate the value of  $\Delta \mathbf{z}_t$  as follows:

$$\Delta \mathbf{z}_t = \alpha \beta' \mathbf{z}_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta \mathbf{z}_{t-j} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \quad (5.7)$$

where  $\alpha \beta' \mathbf{z}_{t-1}$  represents the error correction components  $\sum_{j=1}^{k-1} \Delta \mathbf{z}_{t-j}$  is the vector autoregressive process (VAR).  $\boldsymbol{\mu}$  is a  $(p \times 1)$  vector of deterministic components and  $\boldsymbol{\varepsilon}_t$  is



a  $(p \times 1)$  vector of error terms.  $k$  is the lag period selected by Akaike Info Criterion.  $\Gamma_j$  is a  $p \times p$  matrix of short-term adjustment parameters.  $\alpha$  and  $\beta$  are parameter matrices of dimension  $p \times r$ , where  $r$  is the rank of the matrix:  $\alpha$  represents the loading coefficients and  $\beta$  contains the cointegration relationships, that is, the long-run effects between the variables. Given the small sample size, the maximum number of lags is reduced while the model runs following the indication provided by the AIC and SBC tests. The results suggest a model with  $k = 3$ , whereas the SBC suggests  $k = 1$ . Table 5.5 shows the results of the  $\alpha$  vector containing the estimations of the VECM loading coefficient.

**Table 5.5** VECM loading coefficient

	<i>Loading coefficients</i>		
	$\beta$ (Freight)	$\beta$ (Oil)	$\beta$ (USwheat)
ec1(t-1)	-0.024	0.011	0.012
<i>Std.Dev.</i>	-0.009	-0.012	0.011
<i>P-Value</i>	{0.006}	{0.394}	{0.279}

The  $\alpha$  vector defines the speed of the error correction model. By observing that, it is concluded that when a short-run shock occurs, the larger the parameters, the faster the system will return to equilibrium. Table 5.5 shows that a lack of speed in the adjustment to the shock of the system since betas are very low in the three cases examined. The small error correcting terms confirm the strong relationships among the three variables: the interdependence across these sectors is robust and the integration between these markets is relatively high. These results translate to a constant spillover transmission of price shocks, which immediately gives rise to changes in the dry bulk market.

The cointegration vector resulting from our analysis is given by  $\beta = (1.00, -0.743, -0.457, 1.406)$ ; the estimated cointegration relationships (where the parameters can be regarded as long-run elasticities) are thus expressed in the following equation:

$$\text{FREIGHT} = 1.406 + 0.743 \times \text{OIL} + 0.457 \times \text{USHWHEAT} \quad (5.8)$$

The main highlight of these results is the relatively large size of the parameter linked to oil as well as the parameter for wheat price. Therefore, it is verified that oil shocks have a positive impact on freight price and it is estimated that a shock of one price unit in oil price in the long-run can cause a 74% change in the price of freight rates. This is linked to the cost of operating the vessel and the bunker cost, which are the main revenue risks for ship owners. Although oil price has the largest effect on the freight rate, our analysis indicates that wheat also has a positive effect on the dry bulk freight rate. In the period under study, the estimations show that an increase in the long-run of 1 unit price of grain can affect the price of the route by 45%. In particular, the test results indicate that the wheat price and freight rate variables share a common trend (Dickey Fuller test and Cointegration). Crude oil price is included in the estimation and the causality test shows a direct causality between crude oil price and wheat price. The results obtained from the VECM estimations demonstrate a direct relationship between an increase in oil price and freight rate, but most interestingly, the model provides the evidence showing that wheat price has a direct impact on the freight rate. The fluctuations of the wheat market are thus incorporated in the freight rate without having to discriminate between the supply and demand dynamism of the wheat market. Nevertheless, it is important to evaluate carefully the results obtained in the elasticity analysis. On a final note it is important to emphasise that the primary objective of this chapter is to evaluate the cointegration of Wheat and Freight Rates in a particular period of time (the boom and bust period between 2006 and 2011) and this might affect the final estimation of the coefficients. Therefore, it is recommended to further back-test the result obtained by investigating the price elasticity of Oil, Freight and Wheat over different time samples.

## 5.6 Conclusions

The empirical background of the recent speculative activities in wheat price and freight rate was the motivation for the study in Chapter 5. The main objective was to evaluate whether or not boom and bust cycles can be transmitted between commodity markets and dry bulk freight rates. Based on a weekly time series of wheat price and dry bulk freight rate, the main economic characteristics elapsing between these two markets were identified. The statistical tests (Dickey-Fuller and Cointegration) confirmed a cointegration relationship between wheat market price and freight rate.

The numerical results showed how wheat price and freight rate effectively share a common trend. By implementing a Vector Error Correcting (VEC) model, it was demonstrated that oil shocks have a positive impact on freight price, but that wheat price shocks also induce large changes to the freight rate dynamics. These results are significant for the dry bulk industry indicating that the price of wheat may face an upward trend due to a shock (i.e. speculative investments), and this in turn can stimulate a rise in the dry bulk freight rate.

The analysis has also reached additional: since the elasticity of wheat and oil are significant we can assert that speculative investments may affect freight rates positively. In light of these results, it is observed that a prolonged period of over-liquidity and speculation in commodity markets, due to institutional investors, can cause a steep increase in wheat prices. In particular, the presence can alter the pricing dynamics of agricultural commodities thus exacerbating prices swings and volatility clusters (Irwin, et al., 2009).

Moreover, speculation in commodity markets can threaten the stability of freight rates and therefore causes cascading effects in such a way that it biases not only the efficient

pricing but leads to a distortion in investment and consumption decisions. Shocks to wheat price may move over freight rates and lead to higher profits, over-expectations in the dry bulk industry, and therefore push investment decisions (such as fleet investment). Following the results obtained in Chapter 4 and Chapter 5, the next step in the analysis is to evaluate whether the speculation in Dry Bulk Shipping Market, partially caused by the boom and bust cycle in Commodity market, can be transmitted to ship-owner investment decision and in particular if this can affect port infrastructures and contracting of dry bulk fixtures. In doing so, the Chapter 6 will investigate the micro economic determinants of Dry Bulk Freight rates and will shed a light on the important factors affecting the pricing and the negotiation of Dry Bulk fixtures.

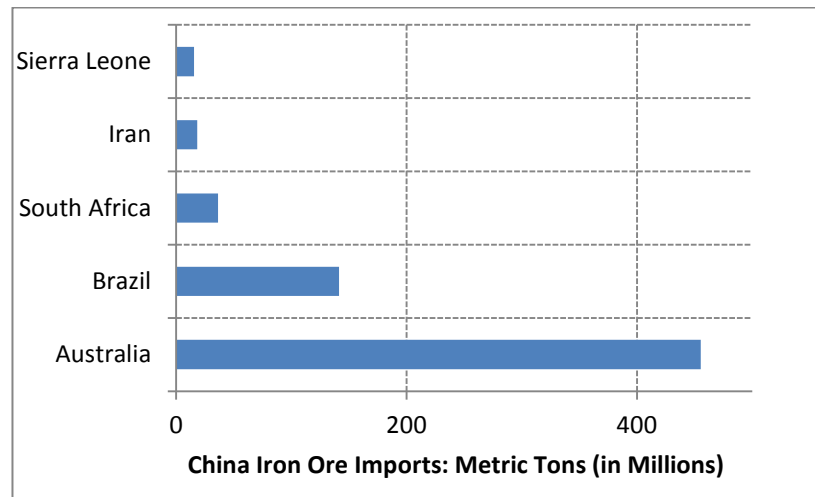
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## **Chapter 6      Determinants of iron ore dry bulk freight rates: structural, specific and market factors**

### **6.1 Introduction**

As the main sector in the shipping industry, dry bulk carriers are large single hull vessels that engage with the transport of “dry” commodities and move enormous quantities of bulk raw materials across the globe. Dry bulk is divided into two main sectors: major bulk and minor bulk (Stopford, 2007). Minor bulk cargo is the handling of mainly agricultural products, minerals, cement, forest products, and steel; whereas major bulk cargo, the vast majority, delivers primarily coal, grain and iron ore.

Iron ore is the main raw material shipped around the world via dry bulk fleets, with 1.5 billion metric tons carried in 2012. According to the World Bank, for the year 2013 China accounted for 67% (820 million tonnes) of world iron ore imports and 48% (775 million tonnes) of world crude steel production; Japan accounted for 11% (136 million tonnes) of world iron ore imports and 7% (111million tonnes) of world crude steel production; and the European Union accounted for 10% (128 million tonnes) of world iron ore imports and 10% (167 million tonnes) of world crude steel production. Figure 6.1 shows, the main Chinese trading partners for iron ore are Australia, Brazil and South Africa.

**Figure 6.1** Main iron ore exporting countries to China. Data Source: MySteel.net database.

The Chinese trading partners shown in the Figure 6.1 are separated by long sea distances, indicating that partners use dry bulk carriers to deliver iron ore to China. Following the trends unveiled in previous chapters, this part of the research proves that not only do commodity prices have an impact on the level of freight rates, but that the structural characteristics of port infrastructures and aspects of the iron ore market are affected by speculation too. Although the existing literature provides different models to investigate the behaviour of dry bulk freight rates at macro and micro level, few studies concentrate on the interactions between freight rates, commodity prices and port infrastructure. Therefore, Chapter 6 aims at filling this gap in the literature by implementing a system of simultaneous equations that investigates the effect of structural (infrastructure) and specific (dry bulk industry) variables on the level of freight rates. Given this background, Chapter 6 assesses the main micro economic determinants of speculation in dry bulk freight rates with a particular focus on iron ore cargoes. First, it is determined the importance of structural factors and iron ore prices on the level of freight rates. Secondly, it tests the presence of regional effects and iron ore industrial effect on the freight rate modelling. And thirdly, it verifies the presence of truncation bias in the estimation due to the large size of cargoes deployed in iron ore trading. By reaching these objectives, Chapter 6 proves that speculation in dry bulk not influences the normal freight

rate pricing mechanism but might distort the port infrastructure endowment and alters the industry structure, both at regional and charterer level.

These objectives are achieved throughout a cross sectional analysis of specific dry bulk factors, structural factors, and iron ore prices against freight rates. Using the Two Stages Least Square (TSLS) methodology, the parameters of interest are estimated and further analyse the determinants of iron ore freight rates using a Heckman model for truncated data. This second phase of the analysis performs a back test analysis in order to verify whether or not further hidden variables explain changes in the level of freight rates. A large dataset of 13 variables, comprising 685 observations for each variable, has been gathered from Thomson Reuters. The results presented in Chapter 6 demonstrate the paramount role played by micro economic determinants of freight rates in transmitting speculative effects; most importantly it is shown how port infrastructures and iron ore prices strongly influence the level of freight rates, market segmentation and infrastructure investment dynamics. Chapter 6 is organised as follows: Section 6.2 provides the rationale for this study; Section 6.3 describes the empirical framework, data and assumptions; Section 6.4 presents a detailed specification of the models, illustrates the results of the analysis and discusses the criticality of the findings; Section 6.5 provides some concluding remarks and policy implications.

## **6.2 Literature review: determinants of dry bulk freight rates**

Investors have always directed their attentions towards maritime investments and shipping markets because of the outstanding role played by this industry and the potential for large profits. Nevertheless, the extremely volatile environment of the shipping business raises risks that need to be identified and evaluated as comprehensively as possible in order to avoid considerable losses (Geman and Smith, 2012). The evaluation of micro and

macro determinants of freight rate plays a remarkable role in managing risks and understanding of fluctuations in supply and demand.

According to the UNCTAD database, between the 1980s and 1990s dry bulk trade increased by 2% on an average annual basis and the overall increase over approximately two decades was 35%. The demand for dry bulk rates is determined by the underlying demand for commodities transported in dry bulk carriers and therefore the demand for raw material in the global production chain (UNCTAD, 2014). In spite of the remarkable role played by commodities in the dry bulk sector upon investment decisions and market profitability, there is still limited literature that discusses the influence of raw materials cycles on the level of freight rates. The studies available are summarised in two main literature strands: macro-economic factors and micro-economic determinants.

The macro research stream presents an indirect relationship between commodity prices and freight rates which evaluates the business cycle influence (Chiste and van Vuuren, 2014), the seasonality patterns of freight rate fluctuations (Kavussanos and Alizadeh-M, 2001), seasonality patterns in dry bulk shipping spot and time charter freight rates (Kavussanos, 2001), and market demand (Evans, 2006). As Stopford (2007) suggests, the demand for dry bulk freight is a multidimensional result that combines economics of commodity markets, international seaborne trade and world economic activity. According to this view, shipping cycles are mainly driven by the interaction of the economic fundamentals in the supply and demand side in which commodities are often used as a first proxy for the underlying relationship (Beenstock and Vergottis, 1993). On the same topic, other studies report how the dry bulk demand side is strongly influenced by the performance of the underlying business cycle; they assess the correlation level between international trade, seaborne commodities and the dry bulk freight rates at a macro level (Veenestra and Franses, 1997; Rander and Göluke, 2007). More recently, Kavussanos et al. (2010) have shown that commodity and freight rate derivatives influence the volatility of the markets thus exacerbating the performance effect of the business cycle over the



industry performance (Kavussanos, et al., 2010). As noted in Lu et al. (2006), the dry bulk shipping market is very volatile and in the past decade the market fluctuations reached a very high level: in concomitance with the boom and bust cycle on major commodity markets, the prices of dry bulk freight rates witnessed high volatility across different vessel classes (Lu, et al., 2008; Dai, et al., 2015).

Natural resources such as iron ore are unevenly distributed and mined in a variety of regions across the world (Bain, 2013). In particular, iron ore's production and consumption hubs are concentrated in few countries and China is the major world buyer of iron ore (International Monetary Fund, 2015). In the past, iron ore prices were derived from a benchmark accounting for the interaction of demand from the Japanese steel makers and the offer of world producers. In the aftermath of China joining the WTO and the rapid surge of iron demand, there was the need to find a comprehensive method to evaluate iron ore prices (Intercontinental Exchange, 2010): the response to this issue was to set a benchmark price at port level as a proxy of the auctions between local major producers and steel makers (Platts, 2016). The main iron ore producers are China, Australia and Brazil while on the demand side of the market the main iron ore consumers are Far East Asian Countries such as Japan, Korea and again China (UNCTAD, 2014). Europe is still a relatively large market with Germany, France, Poland, United Kingdom and Italy absorbing the largest share of consumptions (Eurostat, 2016). In this context, the iron ore market is very fragmented and this characteristic deeply influences the structure of the dry bulk cargo industry.

Although the dry bulk shipping market is often regarded as a perfectly competitive market (Norman, 1979), natural resource are unevenly distributed over the world and the distribution of producers creates market segmentations in the dry bulk industry. In these circumstances, micro level interaction between freight rates, port characteristics and iron ore prices plays a remarkable role in route pricing. Therefore, the study of micro economic determinants of dry bulk freight rates remains a formidable challenge in order to

understand the functioning of the whole industry. As a matter of fact, the dry bulk industry can be divided in a large number of different markets characterised by quality, liquidity and asymmetry of information that largely affect the price of freight rates (Karakitsos & Varnavides, 2014). The micro economic determinants of dry bulk freight rates have been investigated in various studies: the impact of quality of the vessel and markets is investigated by Tamvakis (1995), Tamvakis and Thanopoulou (2000) and Alizadeh and Talley (2011). The empirical analysis of these studies focuses mainly on the interactions of freight rates with vessels characteristics, contract features and route types. More recently, Adland et al. (2016) have concentrated their efforts to investigate the level of freight for both VLCC tankers and Dry Bulk: their seminal study shows that not only micro-economic variables (such as vessel age, carrying capacity and laycan period) have an effect on freight rates but also the charterers and ship-owners characteristics impacts on the freight rate pricing.

On the other hand, Laulajainen (2007) investigates the differences in shipping freight rates and operational profitability for different shipping routes which confirms some specialisation in certain regions of the world for dry bulk cargo; the work shows how the ratio of demand to available ship tonnage plays a clarifying role in explaining dry bulk freight rates for individual routes. Laulajainen (2007) proves that rates are traded at a premium in less liquid markets and there is market segmentation at regional level: although the dry bulk market is characterized by homogenous products and large number of players with low entry barriers, space influences the distribution of cargoes that can commercially compete in the auctions and can meet the loading window (laycan period) at port level.

According to this background, port infrastructure is essential for the efficiency the dry bulk industry and influences the level of freight rates. In very liquid area of the globe, the problem is that iron ore ports are congested therefore the state of port infrastructure influences the market pricing (Meersman, et al., 2012). Iron ore port infrastructure

endowment comprises variables such as number of cranes, maximum draught and storage area at origin and destination ports and the investment decision at port level to enhance the level of infrastructure can modify the cost of shipping iron ore. Some attempts to measure the impact of port characteristics on the cost of waterborne transport are provided in Sanchez et al. (2003); by using a Principal Component Analysis, their study shows how port efficiency impacts on the cost of freight rates as a result of poor port infrastructure and congestions. On a similar note, Wilmsmeier et al. (2006) demonstrate that an increase in port efficiency, port infrastructure, private sector participation and inter-port connectivity help to reduce the overall international maritime transport costs. Although some studies regarding micro-economic determinants of freight rates are presented in the literature, these studies do not model how specific factors, such as the iron ore commodity, and structural factors, namely port characteristics, influence freight rates at the micro level.

### **6.3 Data, methodology and preliminary results**

#### **6.3.1 Research objectives and data description**

For the aims of this research, a dataset of 13 variables with 685 observations each is used. The dataset containing the regressors of the models under scrutiny is split into two main categories. The first group contains the micro-economic variables related to the dry bulk industry itself while the second group refers to the infrastructure characteristics at port level. Accordingly, the first group is called 'specific factors', which refers to the specific components of the dry bulk fleet: vessel age, laycan period, deadweight tonnes, cargo size, freight rate and charterer, iron ore selling at port level, nautical mile distances, fuel prices, and origin region of the bulk cargo shipment. The second set of variables is based on the characteristics of iron ore terminals at port level and includes berth

dimensions, number of berths and facility for loading iron ore cargo. These variables are called 'structural factors'.

**Table 6.1** Specific and structural variables of dry bulk freight rates. Data Source: Thompson Reuters and MySteel.net database. Data Range 2005 to 2014.

	<i>Variable</i>	<i>Description</i>	<i>Units</i>
Specific Factors	<i>Fr</i>	Freight rate for iron ore voyage fixtures	US\$/Metric Ton
	<i>Size</i>	Deadweight tonnage measure of how much weight a ship is carrying or can safely carry.	DWT
	<i>Lay</i>	Laycan period: amount of time allowed in a voyage fixture for the loading of cargo ships.	Days
	<i>Age</i>	Vessel age	Years
	<i>Dist</i>	Distance between port of origin and port of destination	Nautical Miles
	<i>DWT</i>	Cargo size as total amount of iron ore loaded on the vessel	DWT
	<i>Vol</i>	Volatility (14 days freight rate price)	US\$/Metric Ton
Commodity Price	<i>Iron</i>	Iron Ore selling price at port level	US\$/Metric Ton
Structural Factors	<i>Length</i>	Berth Length	Meters
	<i>Depth</i>	Berth Depth	Meters
	<i>Berths</i>	Number of berths available for loading iron ore cargoes	Number
	<i>Loaders</i>	Number of ship-loaders available	Number
	<i>THP</i>	Total Hour Productivity: Total amount of iron ore loaded at berth level	Metric Ton/Hour

Since this Chapter focuses on the micro economic determinants of freight rates as dependent variable the fixtures of dry bulk iron ore cargoes is the key variable under scrutiny. Dry bulk cargo is divided into different classes according to the deadweight tonnes of the vessel loads: Handysize (up to 39,999 DWT), Handymax/Supramax (40,000 to 59,999 DWT), Panamax/Postpanamax (60,000 to 109,999 DWT), Capesize (110,000 to

199,000 DWT) and Very Large Iron Ore Carriers (over 200,000 DWT). Although the dry bulk fleet is largely differentiated into five main size classes, it is worth mentioning that to a large extent the cargoes deployed in iron ore transportation are capesize vessels. The Capesize class is differentiated into three further main categories: Old Capesize (110,000 to 149,999 DWT), Large Capesize (150,000 to 199,999 DWT) and Very Large Iron Ore Carrier Capesize (over 200,000 DWT). As the descriptive statistics in Table 6.2 show, the average cargo size in the data set is 164,841 DWT and the median is 170,000 DWT, which highlights the significant role played by very large capesize vessel in iron ore shipments throughout the world. The rapid expansion of capesize loading capacity has been driven by the necessity to accommodate more iron ore on board in order to exploit the maximum from cargo economies of scale and thus reduce the transport cost. The motivation behind this expanding DWT pattern is mainly due to the relatively cheap price of the commodity cargo and the long-haul iron ore routes sailed across oceans linking producers with end users of iron ore. According to Table 6.2 descriptive statistics for 2014, the average trip for these vessels is 7,000 miles and in some cases may rise above 13,000 miles. The iron ore industry structure of producers and consumers is such that the main exporting countries are Australia, Brazil and South Africa and the main buyers are China, the United States and Europe.

**Table 6.2** Descriptive statistics for Nautical Miles, Age and Cargo Size variables. Data Source: MySteel.net database and Thompson Reuters.

	<i>Nautical Miles</i>	<i>Age</i>	<i>Cargo Size</i>
Mean	6,732.69	6.53	164,841.60
Standard Error	162.23	0.19	589.56
Median	4,156	5	170,000
Mode	4,059	4	170,000
Standard Deviation	3,920.55	4.62	14,247.36

Additionally, the recent boom and bust period in the dry bulk industry has deeply affected the supply of cargoes: the prolonged period of high rates between 2005 and 2009 has induced the ship-owners to renew the fleet by investing in new vessels. First of all, Table 6.3 confirms that East Asia is the market place for iron ore fixtures: between 2005 and 2009, 70.1% of the global iron ore fixtures were directed toward East Asian ports and this number increased to 90% in the period between 2010 and 2014. On the other hand, data emphasize the significant decrease in iron ore shipments towards North and Mediterranean Europe: the number of fixtures drops from 397 in the period between 2005 and 2009 to 140 between 2010 and 2014. This market dualism is similar to other statistics. As Table 6.3 shows, the average age of the cargo operating world-wide has undergone a process of renewal: between 2005 and 2009, the average Age for dry bulk cargoes was 16.4 years as many vessels age was above 30 years. After 2010 the average age drops to 8.45 indicating a consistent restructure of the global dry bulk fleet. Similar patterns are verified for the Laycan period which decreases globally from 10.5 days to 7.7 days with a significant decrease in East Asia. Moreover, Table 6.3 shows that this trend was particularly pronounced in the Far-East Region of the world. Additionally, it is possible to observe that Cargo Size increases in the period between 2010 and 2014: globally the average cargo size goes up from 148,000 DWT to 154,000 and this change is mainly verified in Far-East Asia that witnesses an increase in the average cargo size of 2,000 DWT.

**Table 6.3** Variable Averages: descriptive statistic Dry Bulk fixtures (periods 2005-2009 and 2010-2014). Data Source: Thompson Reuters database.

<b>All World</b>					
<i>Period</i>	<i>Obs.</i>	<i>Age</i>	<i>Fr</i>	<i>Cargo Size</i>	<i>Lay</i>
2010-2014	1,749	10.87	13.21	154,021.15	7.70
2005-2009	2,248	15.67	22.27	147,983.32	10.53
<b>Far-East Asia</b>					
2010-2014	1,505	9.85	13.16	160,407.97	7.37
2005-2009	1,596	15.36	23.08	158,090.85	10.49
<b>Europe</b>					
2010-2014	140	8.06	11.93	104,135.71	10.05
2005-2009	397	15.22	20.27	117,429.47	11.07
<b>All World exc. Far East Asia</b>					
2010-2014	243	8.93	13.49	114,481.48	9.74
2005-2009	652	16.41	20.28	123,241.56	10.61

Although dry bulk cargo technology is a dynamic and fast growing field, it is observed that in order to host such expanding vessel sizes, the technological enhancements must be followed by a comprehensive restructuring of port infrastructures and iron ore terminals. In keeping with this notion, structural factors are critically important for the analysis due to their ability to accommodate large cargo and in their responsiveness with regard to loading cargo. The first characteristics refers to the iron ore terminal hard infrastructure features, namely the berth length and berth depth whereas responsiveness applies to the ease of the vessel to dock at the berth and load the cargo. These factors are represented in the dataset by number of berths available for iron ore loading, number of ship-loaders, and the productivity of ship-loaders measured as the total amount of iron ore loaded per hour. Both of these factors are integral to determine the time between the day the fixture contract is signed and the day the vessel is loaded at port, which is known as the laycan period.

### 6.3.2 Methodology

According to the multidimensional dataset presented, Chapter 6 engages in two aspects of iron ore freight rate modelling: the first model specification tackles the issues of the

main determinants of the freight rates, while the second model investigates the impact of port characteristics on the modelling of laycan periods. Following the background presented in Section 6.2, it is assumed that the iron ore voyage freight rates reflects the specific factors of the vessel such as age, distance to the port, iron ore price, laycan period, cargo size, and volatility. According to prior works developed by Adland et al (2016) and Alizadeh and Talley (2011), the determinants of iron ore freight rates are then investigated using the specific factors as explanatory variables in the following regression model:

$$Fr = \alpha_0 + \alpha_1 Iron + \alpha_2 Dist + \alpha_3 Dist^2 + \alpha_4 Lay + \alpha_5 Age + \alpha_6 Age^2 + \alpha_7 Vol + \alpha_8 DWT + u; u \sim i.i.d. (0, \sigma^2) \quad (6.1)$$

Where  $Fr$  is the freight rate for dry bulk cargo,  $Iron$  is the price of iron ore at port level,  $Dist$  is in nautical miles distance port of origin to port of destination,  $Lay$  is the laycan period in days,  $Age$  is the year age of the vessel,  $Vol$  is the volatility in the market calculated over the last 14 days and  $DWT$  is the iron ore loaded on the cargo ship.  $u$  represents the error term that according to the model assumption is independent and identically distributed with average equals to zero and constant variance equals to  $\sigma^2$ .

Using this specification, the model accounts for two non-linear effects for freight rate pricing. The first non-linear variable is age-squared and the rationale for this effect is given by the fact that operational performance, technological efficiency and the quality standard of ships decline as they get older; consequently their hire rate is assumed to be a nonlinear function of age. The second non-linear variable is distance squared and the rationale for including this variable is the assumption that freight rates are proportional to distance with a non-linear function. The non-linearity assumption has already been tested in the literature: Dick et al (1998) show that age has a non-linear effect on the level of freight rates while Alizadeh and Talley (2011) demonstrate that Age increases the freight rate but this effect tends to diminish with the increase in the variable. On the other hand



the assumption of the non-linear effect of nautical miles is dictated by the iron ore industry composition: the main production sites often overlap and given its iron ore bulk characteristics producers must be close to consumers. Therefore, it is expected that distance positively affect the cost of shipping however this cost should slowly decrease as the distance from buyers increases ( Behar & Venables, 2011).

Following these assumptions regarding the behaviour of laycan period, the second step of the analysis estimates the factors influencing the time gap between the signing of the contract and loading of the vessel. This aspect represents a novelty in the literature because it estimates the laycan period based upon the characteristics of the loading ports and iron ore port terminals. In fact, the determinants of laycan periods are investigated by regressing laycan on the structural explanatory variables, namely, port characteristics, number of berths, ship-loaders, and berth dept. Therefore, the laycan regression model is specified as:

$$\begin{aligned} Laycan = & \beta_0 + \beta_1 Lenght + \beta_2 Depth + \beta_3 Berths + \beta_4 Loaders + \beta_5 THP \\ & + v; v \sim i.i.d. (0, \sigma^2) \end{aligned} \quad (6.2)$$

Where  $v$  is the error term independent and identically distributed with average equal to zero and constant variance equals to  $\sigma^2$ .

In order to provide preliminary results to support the present research, a linear regression (Ordinary Least Squares - OLS) estimates the parameter of interest in Equation 6.2. Table 6.4 presents the relationships between laycan period and structural variables.

**Table 6.4** OLS model. Dependent variable: Laycan.

	<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
$\beta_1$	Length	-0.0187	0.0020	-9.2482	0.00	***
$\beta_2$	Depth	1.0674	0.0536	19.9002	0.00	***
$\beta_3$	Berths	-0.7837	0.0686	-11.4229	0.00	***
$\beta_4$	Loaders	-0.8059	0.5312	-1.5170	0.03	**
$\beta_5$	THP	-3.91e-05	8.50e-05	-0.4601	0.64	
Sum squared resid		2,983.66 S.E. of regression			2.27	
R-squared		0.88 Akaike criterion			2,619.83	
Schwarz criterion		2,641.67 Hannan-Quinn			2,628.34	

In Table 6.4, five out of a total of six variables are significant in determining the duration of the laycan period. Furthermore, the results emphasise a negative relationship between berth length, number of berths and shiploaders, and the laycan period. This would confirm the practitioner's view which underscores the importance of port infrastructure in decreasing laycan periods. Although the OLS estimations provide an important preliminary picture, for the aim of Chapter 6, a system of equations is implemented to account for the important simultaneous relationship between laycan and freight rates (Alizadeh and Talley, 2011). According to the authors, freight rates and other terms of the contracting are negotiated simultaneously so they may influence each other. Nevertheless, their specification of the model does not take into account the important characteristics of the port that help to determine the duration of the laycan period. In order to fully incorporate the results provided by Alizadeh and Talley (2011), the methodology incorporates this relationship into the modelling and comprehensively describes how structural variables simultaneously influence the laycan period. It follows that the model implements a two-stage analysis based on the system of equations:

$$\left\{ \begin{array}{l} Laycan = \beta_0 + \beta_1 Fr + \beta_2 Vol + \beta_3 Lenght + \beta_4 Depth + \\ \beta_5 Berths + \beta_6 Shiploaders + \beta_7 THP + u; \\ u \sim i.i.d. (0, \sigma^2) \\ \\ Fr = \alpha_0 + \alpha_1 Iron + \alpha_2 Dist + \alpha_3 Dist^2 + \\ \alpha_4 Lay + \alpha_5 Age + \alpha_6 Age^2 + \alpha_7 Vol + \alpha_8 DWT + v; \\ v \sim i.i.d. (0, \sigma^2) \end{array} \right. \quad (6.3)$$

This comprehensive specification overcomes the bias created by the simultaneous relationships and omitted variables. This bias arises when a model does not account for the multidimensional aspects of freight rates. In order to derive the parameters of the simultaneous system of equations, econometricians have developed different techniques that tackle the main weaknesses of normal OLS estimations. A common way is to apply the Instrumental Variables (IV) methodology. This methodology overcomes the problem created by the Omitted Variables bias in the case of a single equation estimator (Staiger and Stock, 1997). Nonetheless, when there are multidimensional factors in a system of equations for sectional data, Two-Stage Least Squares (TSLS) is the widely used methodology to estimate consistent parameters and solve the problem of omitted-variables bias present in the single-equation estimation (for a detailed discussion see: Stock & Watson, 2011). In this case, studying the TSLS takes the following notation: the first stage regression, called auxiliary regression, uses structural port variables and freight rates to determine the 'predicted values of laycan. In the second stage regression, laycan predicted values are then used as instrument variables for the main regression where the micro determinants of freight rate are estimated.

Before starting with the core quantitative results of Chapter 6, some statistical conditions must be satisfied in order to provide non-biased estimations of the TSLS model. The first condition that needs to be satisfied is that the auxiliary regression, without the endogenous terms, provides (statistical) significant relationships between the dependent variable and the exogenous covariates (Stock and Watson 2011). Table 6.1 have already provided the significant relationship between the variables under scrutiny and the laycan

period; therefore a further diagnostic test for the TSLS model is now carried out. A second condition that must be satisfied is the absence of covariance between the error term of the second stage regression and the structural factor exogenous variables in the auxiliary regression, namely:

$$\text{Cov}(\text{Structural Factors}, u) = 0$$

Where Cov is the covariance, Structural Factors includes all the exogenous variable that represent the port infrastructure characteristics and  $u$  is the error term of Equation 6.1. A test on the covariance between these two elements is thus performed and the results are provided in Table 6.5.

**Table 6.5** Covariance Matrix between error term  $u$  and structural factors.

<i>Covariance Matrix</i>	<i>Berth Length</i>	<i>Berth Depth</i>	<i>Number of Berths</i>	<i>Number of Shiploaders</i>	<i>THP</i>
$u$	-0.1153	-0.1570	-0.0614	-0.1149	-0.1020
<i>P-Value</i>	0.0081	0.0003	0.0593	0.0083	0.0191

The results confirm the hypothesis that the structural factors used in this Chapter are effectively exogenous variable and are not correlated with the error term of Equation 6.1. The statistical evidence provided by Table 6.5 depicts a situation where the entire set of structural factors is significantly uncorrelated with the residual of the Equation 6.1. Given these evidences and these results, it is now possible to proceed to the next step where the system of equation parameters are estimated and tested to evaluate the micro economic determinants of freight rates.

#### 6.4 Micro determinants of freight rates: empirical results

Following the model specified in Section 6.3, the estimation of the TSLS are presented and discussed in this Section. The data sample is restricted to the years 2012 to 2015 for

a lack of port infrastructure data prior to 2012. For each variable included in the model, there are 583 data points: this represents a good number of observations which allows the coefficient estimations without concerns over the degree of freedom lost.

Although the model estimation is an exercise carried out altogether at both stages, for the purposes of the analysis and to discuss the outcomes in depth, the results of the auxiliary regression are firstly presented separately in two sub-sections. A third paragraph completes Section 6.4 by providing the model back testing in order to verify further relationships between micro economic determinants of freight rates and other shipping variables.

#### 6.4.1 Determinants of laycan periods: the auxiliary regression

This subsection provides the results of the first stage Ordinary Least Square for the dependent variable laycan period. If taken out from the context of a TSLS specification, the model under scrutiny appears as following:

$$\begin{aligned} Laycan = & \beta_0 + \beta_1 Fr + \beta_2 Vol + \beta_3 Lenght + \beta_4 Depth + \beta_5 Berths + \beta_6 Loaders \\ & + \beta_7 THP + u; u \sim i.i.d. (0, \sigma^2) \end{aligned} \quad (6.4)$$

According to this specification, first, the auxiliary regression estimates the fitted values of laycan period used to estimate determinants' freight rates in the second stage. Secondly, it also tackles the issue of which factors influence the time period between contract signing and duration of the vessel in laycan. The first two coefficients ( $\beta_1, \beta_2$ ) estimated in Equation 6.4 indicate the simultaneous components, whereas the last five coefficients show how port infrastructures influence the duration of laycan periods. In addition to some fitting metrics for the model, Table 6.6 presents the results of the regression.

**Table 6.6** Auxiliary regression for TOLS model. Laycan period as dependent variable.

	<i>Variables</i>	<i>Coeff</i>	<i>p-value</i>	
$\beta_1$	Fr	0.0332	<0.00	***
$\beta_2$	Vol	0.0061	0.36	
$\beta_3$	Length	-0.0179	<0.00	***
$\beta_4$	Depth	1.0077	<0.00	***
$\beta_5$	Berths	-0.7231	<0.00	***
$\beta_6$	Loaders	-0.9892	<0.00	***
$\beta_7$	THP	-0.0048	0.02	**
R-squared	0.88	S.E. of regression	2.27	
Schwarz criterion	2,639.41	Akaike criterion	2,617.57	

The results in Table 6.6 show that the estimated parameters are similar to those observed in the single equation model in Table 6.4. Therefore, the backbone assumption of the model is confirmed by the statistical evidence of the TOLS in step one of the analysis. Furthermore, the results suggest a strong relationship between duration of laycan period and structural variables of the port. The significant and negative values of number of berths and ship-loaders confirm the hypothesis that iron ore terminal infrastructures influence the time period between the signing of the contract and the loading of cargo. The more sophisticated the infrastructure at port level, the lower is the laycan period and the less time taken by the loading phase. This result is confirmed by the negative parameter of the equipment for cargo loading, which shows how the infrastructure for iron ore cargo impacts negatively on the laycan period. These results are in line with the findings of other studies focussing on port infrastructure and transportation costs: as emphasised in Clark et al. (2004), the inefficiency of port infrastructure can positively affect the freight rates to a similar extent that trade barriers restrict international trade (Clark, et al., 2004). Therefore, this outcome further emphasises the significant role of port infrastructure, in particular in the iron ore dry bulk sector. Charterers and ship-owners focus on the level of available infrastructure when it is time to sign a contract: if the port

responds promptly to the needs of cargo loading, this significantly influences the negotiation of freight rates. If a port is well developed, the laycan period tends to diminish and the freight rate negotiation is carried out with ease. On the other hand, in cases where the port infrastructure are not developed sufficiently, the situation demands that additional time be consumed to deal with the cargo loading phase which increase the cost for both ship-owners and charterers. Additionally, the results show a significant positive relationship between the level of the freight rates and the laycan period. This is in line with other studies in the field that confirm a positive premium for laycan periods: as the freight rate increases, the laycan period increases (Alizadeh & Talley, 2011; Adland, et al., 2016).

On a final note, it is important to observe that TSLS presents a relatively high R square (0.88). As this number is the fraction by which the variance of the errors is less than the variance of the dependent variable it gives a preliminary indication of how good is the fitting of the model. Accordingly, the TSLS R-squared is 0.88, the variance of its errors is 88% less than the variance of the dependent variable and the standard deviation of its errors is 68% less than the standard deviation of the dependent variable. That is, the standard deviation of the regression model's errors is about 1/3 the size of the standard deviation of the errors that you would get with a constant-only model. Nevertheless, high level of R-square might indicate the presence of multicollinearity between regressors. Although multicollinearity does not undermine the OLS assumptions (OLS estimates are still unbiased and Best Linear Unbiased Estimators), the confidence intervals for coefficients tend to be very wide and t-statistics tend to be very small. Coefficients will have to be larger in order to be statistically significant, i.e. it will be harder to reject the null when multicollinearity is present. In this context, although the coefficients are unbiased it is not possible to do inference on them, therefore it is recommended to test for the presence of multicollinearity. According to this background, the test on multicollinearity between the regressors: on a first basis it was checked that no significant correlations are found between the independent variables and second that the variance inflation factors

are lower than 10 (Stock & Watson, 2011). According to this result, the presence of multicollinearity is rejected.

However, there is one caveat: given the relationship between port infrastructures, freight rates and laycan period, if fluctuations in freight rates are caused by speculative behaviours, it is possible that port investment decisions are pushed beyond sustainable levels. When freight rates are relatively high and revenues yields are sustained, in order to tackle the port efficiency and enhance the port output, operators might decide to assume more risks and invest in the port. With a short period investment view biased by the freight rate, this effect might lead to over-investments which exceeds the effective port needs thus undermining the sustainable growth of the port itself. This over-investment cycle is described in the literature as contagion effect. As shown in Rosser et al. (2012), periods of sustained and high return can cause a misallocation of capital toward unproductive investments; when the speculative cycle comes to an end the investments shortly go bankrupt. Given this first set of results, the next sub-section further investigates the relationship between iron ore and freight rates and presents the estimation of iron ore freight rate determinants.

#### 6.4.2 Determinants of freight rates: second stage regression

The second stage of the analysis estimates the determinants of freight rates using the results obtained in the auxiliary regression. The “fitted laycan” supports the main model and helps to predict the determinants of dry bulk freight rates by tackling at the same time the issue of simultaneous effects between freight rates and laycan itself. An important relationship that this analysis aims to verify is the presence of a positive relationship between iron ore prices and freight rates. In order to achieve these results, the second stage regression follow this specification:

$$Fr = \alpha_0 + \alpha_1 Iron + \alpha_2 Dist + \alpha_3 Dist^2 + \alpha_4 Lay + \alpha_5 Age + \alpha_6 Age^2 + \alpha_7 Vol + \alpha_8 Size + v; v \sim i. i. d. \quad (6.5)$$



Table 6.7 provides the results of the second stage and shows the p-value associated to the coefficients and the fitting index for the model.

**Table 6.7** Second stage regression for TOLS model. Iron Ore Freight rate as dependent variable.

	<i>Variables</i>	<i>Coefficien t</i>	<i>p-value</i>	
$\alpha_0$	<i>constant</i>	7.28226	<0.00	***
$\alpha_1$	<i>Iron</i>	0.03243	0.00	***
$\alpha_2$	<i>Dist</i>	0.07713	0.00	***
$\alpha_3$	<i>Dist<sup>2</sup></i>	-0.00343	-0.00	***
$\alpha_4$	<i>Lay</i>	-0.0556	0.00	***
$\alpha_5$	<i>Age</i>	-0.0479	0.40	
$\alpha_6$	<i>Age<sup>2</sup></i>	0.00217	0.49	
$\alpha_7$	<i>Vol</i>	0.05565	<0.00	***
$\alpha_8$	<i>Size</i>	-0.045	<0.00	***
<i>R-squared</i>	0.92	<i>S.E. of Regression</i>	1.63	
<i>Schwarz Criterion</i>	2045.04	<i>Hannan-Quinn</i>	2026.86	

The coefficient estimations in Table 6.7 indicate that six of the eight parameters are statistically significant. In this second stage, the two coefficients that are not significant are cargo age and cargo age squared. Given these results, it is not possible to confirm the relationship between cargo age and freight rate, but this may be due to the sample size: this research uses fixtures dated 2013, 2014 and 2015: after the boom and bust cycle of 2009, the dry bulk fleet has been extensively renewed and the average cargo size for the market is now very low. On the other hand, vessel size coefficient is negative and significant, which confirms the presence of economies of scale in iron ore cargo: the increase in vessel size makes the transportation of iron cheaper by 4.5% per unit. Furthermore, there is a premium paid on the distance, but this effect tends to reduce for

long haul routes: the coefficient  $Dist$  is positive and significant, but  $Dist^2$  is negative, suggesting a non-linear relationship that decreases as nautical miles sailed increases. Volatility has a positive effect on freight rate too: if we take this variable as a proxy for risk in the contracting period, the result shows how, as levels of volatility increase, an additional freight premium is paid to ship-owners.

Laycan period is negative and this effect can be caused by traders (buyer, seller, etc.) who try to fix the contract as soon as possible in order to get the best rates before they increase further. Conversely, a positive and significant relationship is observed between iron ore price and freight rate: this effect is quantified at 3.2% per unit and demonstrates that an increase in iron ore price leads freight rates upwards. This result has very strong business and policy implications: the general price level of commodities influences freight rates and, consequently, the profitability of the entire industry. The profit spillover from commodity to freight rates is an effect that not only determines freight cycles but also ship-owner investment, scrapping decisions, and laycan periods. Therefore, this second step of the analysis shows how the iron ore market directly influences the dry bulk industry by means of the commodity price level. In the previous section, it was proved that structural port characteristics determine the contracting time for freight rates, this second stage provides a broader picture of how multi-dimensional factors arising from commodity markets directly changes the profitability of the industry and its main dynamics. Given these interesting relationships arising from the analysis, it is possible that the modelling contains a caveat related to the particular structure of the iron ore industry (regional specialisation and market players) and dry bulk cargo sizes. Therefore, the next section tests whether specific factors can bias the results of the estimations and the inference provided so far.

### 6.4.3 Back-testing for further hidden relationships

The back testing phase of Chapter 6 addresses the presence of hidden factors which could potentially influence the level of freight rates, the coefficient estimations and the extent of their influence. This final analysis is divided into two main parts: a first testing model verifies whether market factors influence the level of freight rates, namely, iron ore regional advantages and mining company power to negotiate better deals with ship-owners. A second test evaluates whether the presence of truncated data at cargo size level affects the estimations presented in the former section.

#### Regional and market factors test

The iron ore industry is characterised by an international and very dynamic market place dominated primarily by two countries that export iron ore via dry bulk cargoes: Australia (530,000 tonnes produced per year) and Brazil (398,000 tonnes produced per year). The main market players of iron ore are Vale S.A., a large Brazilian mining company and Rio Tinto is an Australian mining company. This particular market situation may generate a regional effect for freight rate and could potentially allow the two main market players to obtain different types of freight rates, when as charters, they deal with counterparties to negotiate voyage contracts.

In order to test these hypotheses, Section 6.4.3 draws data from a set of 4 dummy variables: one dummy for Australia and one for Brazil are created; also a dummy variable for the charters Vale and Rio Tinto are prepared to further test for regional effects. The dummy variables are then added to TSLS model presented in former section and estimations are re-run. The results are provided below in Table 6.7.

**Table 6.8** Testing for specific industrial factors in iron ore bulk cargo.

<i>Variables</i>	<i>Coefficient</i>	<i>p-value</i>	<i>Variables</i>	<i>Coefficient</i>	<i>p-value</i>
<i>const</i>	6.4224	0.00	<i>const</i>	7.24011	<0.00
<i>Size</i>	-0.0039	<0.00	<i>Size</i>	-0.0034	<0.00
<i>Age</i>	-0.0067	0.22	<i>Age</i>	-0.0439	0.43
<i>Dist</i>	0.0093	0.01	<i>Dist</i>	0.0063	0.00
<i>Iron</i>	0.0037	<0.00	<i>Iron</i>	0.0031	0.01
<i>Vol</i>	0.00544	<0.00	<i>Vol</i>	0.0545	<0.00
<i>Age</i> <sup>2</sup>	0.0028	0.33	<i>Age</i> <sup>2</sup>	0.0019	0.50
<i>Dist</i> <sup>2</sup>	0.0036	0.04	<i>Dist</i> <sup>2</sup>	0.0044	0.00
<i>Australia</i>	0.4538	0.41	<i>RIO</i>	0.1477	0.39
<i>Brasil</i>	0.11	0.00	<i>VALE</i>	0.204	0.02
R-squared	0.92		R-squared	0.93	
S.E. of Regression	1.52		S.E. of Regression	1.61	
Schwarz Criterion	2,038.90		Akaike Criterion	2,010.48	
Akaike Criterion	1,996.24		Schwarz Criterion	2,053.16	

The coefficient estimations shown in Table 6.8 verify the sign of the main coefficients under investigation, and the main results are confirmed in an unbiased way. However, the regional and industrial patterns arising from our test are noteworthy. Since Brazil shows a competitive disadvantage as an iron ore trading region compared with Australia (and this effect also translates to Vale, the Brazilian mining company), this statistical evidence confirms the presence of regional factors in voyage freight rates for iron ore, and industrial factors that increase the transport cost for iron ore exports from Brazil. More specifically, Brazil and Vale bear additional costs to transport iron ore across the globe; this trend is the result of the largest iron ore importer: China. For this reason, Vale has started to expand its own fleet, to purchase very large iron ore cargoes or ships, and to enter into

long-term chartering agreements (15+ years) in order to meet the increasing iron ore demand from China.

### **Heckman model test**

The truncation test verifies whether the freight rate model implemented in Section 6.4 is biased by a self-selection sample. From the literature and practitioners it is known that, in the case of iron ore freight rate, mainly large vessels are deployed to transport the commodity over long haul ocean trips. Historically, technological improvements have given rise to reductions in freight rates and volatility, and increases in international trade of, for example, raw materials with low ratios weight/value (Lundgren 1996; Limao and Venables 2001; Hummels 2001; Hummels et al. 2009). Cargo ships have a carrying capacity of, on average, 150,000 DWT with some as high as 200,000 DWT. Therefore, in the sample mainly large cargo ships are observed, although some on the order of 100,000 DWT still engage in the transportation of iron ore.

This effect could potentially lead to bias in the estimation of the parameters for freight rates: according to our TSLS model presented in Section 6.4.2, larger vessels have an advantage to obtain cheaper freight rates. This pattern can arise in particular when port infrastructures are not developed sufficiently to load very large capsized cargoes and/or do not have the possibility to access the freight market for very large vessel types. As Green (2003) has observed, the selection bias problem arises due to an incidental or structural truncation of the sample. So, to overcome this weakness econometricians have developed models to tackle the issue of truncation and in particular among those, the Heckman model applies the moments of the incidentally truncated bivariate normal distribution to a data-generating process similar to our situation in this study. Following Heckman's (1976) work, a model to verify whether port characteristics can cause a truncation in the dataset that creates a bias in our estimation is specified as following: the

selection variable is cargo size and the explanatory variables are the structural factors used in the former regressions. Accordingly, two tests are performed. The first test uses as the truncation point cargo size greater than 150,000 DWT while the second test uses the truncation point of 110,000 DWT. This decision is taken because these are the main cargo sizes available in the voyage market. The model consists of two equations: the first is the selection equation, defined as:

$$Z = \beta_1 Length + \beta_2 Depth + \beta_3 Berths + \beta_4 Loaders + \beta_5 THP + u; u \sim i.i.d. (0, \sigma^2) \quad (6.5)$$

where Z is a binary generated according to:

$$Z \begin{cases} 1 & \text{if } Z > 150,000 \text{ DWT or } 110,000 \text{ DWT} \\ 0 & \text{otherwise} \end{cases}$$

The second equation is the linear model of interest and is specified as following:

$$Fr = \alpha_0 + \alpha_1 Iron + \alpha_2 Dist + \alpha_3 Dist^2 + \alpha_4 Lay + \alpha_5 Age + \alpha_6 Age^2 + \alpha_7 Vol + \alpha_8 Size + \alpha_9 \gamma + v; v \sim i.i.d. \quad (6.6)$$

The equation above highlights the importance of the  $\gamma$  coefficient, which provides a synthetic picture of truncation in the sample: if the coefficient is significant, a possible truncation bias is present in the sample. Following this specification, the coefficients are estimated using the Maximum Likelihood Estimation (Heckman 1979) with results of the two regressions presented in Table 6.9. The first two columns show the coefficients and p-values for truncation point >150,000DWT and the last two columns on the right-hand side list the estimations for truncation point >110,000DWT.

Table 6.9

Heckman model for truncation test.

		<b>Selection variable: &gt;150,000DWT</b>		<b>Selection variable: &gt;110,000DWT</b>	
	<i>Variables</i>	<i>Coefficient</i>	<i>p-value</i>	<i>Coefficient</i>	<i>p-value</i>
$\alpha_0$	<i>const</i>	2.4493	0.21	4.7795	0.02
$\alpha_1$	<i>Iron</i>	0.0318	<0.00	0.0038	<0.00
$\alpha_2$	<i>Dist</i>	0.0006	0.00	0.0019	<0.00
$\alpha_3$	<i>Dist<sup>2</sup></i>	0.0043	<0.00	0.0021	0.13
$\alpha_4$	<i>Lay</i>	-0.0633	0.02	-0.0551	0.14
$\alpha_5$	<i>Age</i>	-0.0150	0.77	-0.0272	0.70
$\alpha_6$	<i>Age<sup>2</sup></i>	0.0011	0.70	0.0011	0.78
$\alpha_7$	<i>Vol</i>	0.0541	<0.00	0.0570	<0.00
$\alpha_8$	<i>Size</i>	-0.0016	0.01	-0.0004	0.95
$\alpha_9$	$\gamma$	1.5368	0.00	-0.0831	0.94
<b>Selection Equation</b>					
	<i>Variables</i>	<i>Coefficient</i>	<i>p-value</i>	<i>Coefficient</i>	<i>p-value</i>
$\beta_1$	<i>Length</i>	0.0057	<0.00	0.0039	0.05
$\beta_2$	<i>Depth</i>	-0.2580	0.06	-0.3699	0.00
$\beta_3$	<i>Berths</i>	0.2824	<0.00	0.0060	0.98
$\beta_4$	<i>Loaders</i>	1.8459	<0.00	2.21604	0.03
$\beta_5$	<i>THP</i>	-0.0028	<0.00	-0.0003	0.00

The coefficients estimated by the two Heckman models confirm the evidence of our TSLS estimations. Additionally, in Table 6.9 the pivotal role played by the structural factors in the variable selection process it is emphasised, which in turn sheds light on the remarkable effect of infrastructure in the dry bulk sector. In both models, the estimated coefficients are statistically significant and show how hard port infrastructures are able to attract cargoes for the trade of iron ore. In particular, it is observed that in the case of the 150,000 DWT truncation point, all the signs of the coefficients match the previous estimation provided by TSLS. The truncated observations comprise 8.5% of the total sample, and we observe that for truncation point >150,000 DWT, the  $\gamma$  coefficient is not statistically significant. This statistical evidence suggests that the selection bias in the least squares estimator is absent for this truncation point.

On the other hand, the Heckman model for truncation point 110,000 DWT performs poorly and only a few parameters are significant. Nevertheless, we strongly suggest that this effect may be derived due to the small number of truncated data (only 3.8% of total sample). Despite this caveat, the  $\gamma$  coefficient for 110,000 DWT truncation point is statistically significant, indicating a possible truncation bias in the estimations. This result is not surprising: the effect could be caused both by the infrastructure characteristics of a loading port and by the market characteristics for iron ore trading. As mentioned earlier, the iron ore freight rate market relies on long haul distances and cargo economies of scale effects, which create a natural truncation in the sample of cargo size selected for the aims of this study. Therefore, as main drawbacks of this approach, the inferences derived from these models are applicable to iron ore freight rates only.



## 6.5 Conclusions

Chapter 6 focussed on the main determinants for iron ore freight rates with a particular focus on the Far-East Asia iron ore market. In order to investigate broadly the effects of structural port factors, iron ore prices and maritime specific factors on the level of freight rates, a Two Stage Least Square analysis and back-testing of the empirical results were provided. The research results of Chapter 6 have provided evidence showing how iron ore freight rates are influenced at the micro economic level by the structural characteristics of ports' iron ore terminals and iron ore market factors. In addition, a significant relationship between cargo features and the level of freight rates was found; in particular, the results obtained from the Heckman model suggested that cargo size plays a remarkable role in the estimation of the coefficients. Four main results of this analysis may be summarised. First, port infrastructures and iron ore terminals have a direct impact on the laycan period and time elapsing between arrival and loading of iron ore cargoes. The number of available berths, ship length, and ship-loader productivity significantly diminish the laycan periods, thus decreasing time cost for charters and ship-owners. Second, the maritime-specific factors still have the major responsibility in determining the level of freight rates: nautical distance, cargo size, volatility, and laycan period play a pivotal role in the bargaining process of the iron ore voyage freight contract. Third, there is a consistent regional effect and iron ore industrial structure influencing freight rates: Brazil and its main mining company, Vale, pays higher voyage freight rates in comparison to Australia and its largest company, Rio Tinto. This effect has triggered a recent massive investment plan in which Vale buys very large iron ore cargoes and enters into long-term chartering agreements in order to stay competitive in the world's iron ore market.

Fourth, through an application of the Heckman model, it is shown how cargo size plays a significant role in the iron ore dry bulk industry: vessels employed for iron ore trading are suitable for large long haul distances, the findings of this study are therefore not applicable to smaller vessels. However, the conclusions drawn from the analysis can be

applied to iron ore freight rates only. In the case of grain trading, which generally relies on dry bulk cargoes of minor sizes, further analyses should be performed.

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## **Chapter 7    Regional effects of port Free Economic Zones on Real Estate speculation: the Korean case study**

### **7.1 Introduction**

As seen in previous chapters, the dry bulk industry is prone to boom and bust cycles that become speculative phases in periods of excessive market exuberance. Additionally, it has been shown that these speculative effects shouldn't be treated as isolated industrial phenomena but contextualised in a multidimensional framework. The interrelations between commodity markets and freight rates leads to market spillovers hence, speculation can be transmitted from one market to another. As shown in Chapter 6, the important role played by freight rates in leading the industry investment decision has an effect on the regional dynamic, thus spreading speculative periods to the regional economy. As the port connects the sea with the inland it plays the role of the gateway where the speculative effect can move from the Dry Bulk Industry 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 may transform an underdeveloped area into a modern port and can make the port 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) are often implemented in order to foster regional economic activity, attract new business activities and investments towards port cities (Song, 2015) (Xing, 2014).

However, long term regional benefits generated by port policy (Nijkamp, et al., 1990), such as FEZ, can be undermined by speculative investments; in these circumstances, the development policy can overheat the real estate investment cycle, create excessive expectation regarding future performance, and thus drive land values upward by creating a speculative bubble (Malpezzi, 2000). Therefore, it is paramount to gauge the extent to which FEZ policy may develop in terms of excessive expectations and speculation in the real estate market.

This is particularly interesting in the case of South Korea, a far-east tiger economy, which has been among the fastest growing OECD economies during the past decade. Over the past 10 years, South Korea returned an average annual growth of ten percent, mostly fuelled 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). As a response to those challenges, in the past 20 years, the Korean local authority launched an ambitious program to develop Free Economic Zone in the largest port cities of the country. The program aims to attract foreign investments, prompt innovation and boost international trade and finance.

Within the Korean economic context, in the last decades the major social and economic problems have been the prolonged and sustained housing price growth. As La Grange and Jung (2004) claim, the process of market liberalisation and credit expansion in South Korea have provided fertile grounds to speculators and caused a boom and bust cycle in the real estate market. In the aftermath of the speculative cycle of the 1990s, Korean government implemented policies to prevent future speculation in the real estate market. Nevertheless, as Kim (2005) emphasises, these policies are not effective when the market

becomes irrational: the shortage of housing supply creates inelastic demands that in combination to low interest rates policies may trigger a boom and bust cycle in the real estate market (Kim, 2005). As a matter of fact, between 1999 and 2009, Korea witnessed a dramatic increase in real estate prices, thus generating distortions in home equities, creating housing affordability gaps and leveraging the financial sector (Ha, 2010).

Given this background, the main objective of this Chapter is to examine whether port characteristics and the creation of FEZ in South Korea may have boosted irregular real estate patterns, determined speculation and thus undermined the potential long term benefits unlocked by FEZ. In doing so, Free Economic Zones, port performances and real estate prices are analysed in the following South Korean cities: Busan, Incheon and Ulsan.

The data are collected from Central Bank of Korea and Korean Real Estate Companies for port city with FEZ: Busan, Incheon and Ulsan. These cities are then grouped according to the type of port located in each city: gateway ports, multi-purpose ports and specialised ports. The quantitative analysis is divided in three steps which aim to first, evaluate whether or not the performance of real estate market is in line with the main economic indicators of city economy. Secondly, assess if there is a significant difference in risk perceptions between FEZ real estate performance between gateway, multi-purposes and specialised ports. And thirdly, verify whether the presence of FEZ creates a leapfrogging effect in the real estate market.

The results of the study demonstrate the negative effects of speculation in port development and FEZ performance. Although South Korea has already created a regulation to prevent speculative behaviours, this Chapter brings to the forefront two important political economic considerations for regional development. First, FEZ plays a pivotal role (dynamo effect) for local development by enhancing regional attractiveness, competitiveness and agglomeration but they might provide fertile ground for real estate

speculation. Secondly, in order to achieve integral results, FEZs should be tailored upon the characteristics of the port area.

Following these objectives, Chapter 7 is organised as follows: Section 7.2 provides the rational background to this study and presents quantitative evidence regarding the macro-economic trends in South Korea, the main cities and FEZ; Section 7.3 describes the empirical framework, data and assumptions; Section 6.4 presents the detailed specification of the models, illustrates the results of the analysis and discuss the criticality of the research findings; Section 7.5 concludes the chapter by providing the final remarks and policy implications.

## **7.2 Speculation and Free Trade Zones: case study motivations**

As emphasised by the Regional Economic theory, today's economic geography is characterised by the concentration of economic activities in cities (Krugman, 1993). Specialisation, economy of scale and market interactions have increased the level of urbanisation 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 maximisation of growth returns and minimisation 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, urbanisation patterns and population increase (Fujita & Mori, 1996).

This is particularly true in the case of many Far-East Asian countries where a large share of the population and of the economic activity is concentrated in Port Cities (Merk, 2014). In these instances the objective is twofold: maximising production output while minimising international trade and transportation cost. In fact, Indonesia, China, Singapore, Thailand, China and South Korea have all developed a solid network of port cities that are able to fulfil the international trade demand and import/export of semi/final manufactured goods (Feng, et al., 2012). In the case of Far-East Asia, port cities are not merely departure

cities from the point of view of manufactured good but are arrival cities for investment flows and labour force (Saunders, 2012).

In fact, port cities are dynamic and vibrant places where a number of people move in order to find new opportunities or simply to start a new job. As the real estate market is the first responsive variable in a change in the level of investments or population (Crowe, et al., 2013), port cities are exposed to sudden shifts in demand for house or business properties. Sudden changes might be driven by over-expectations or excessive exuberance regarding the future performance of the port city itself. However, speculative effects in port cities can be triggered by economic policy implemented at regional or national level.

As a matter of fact, port cities leverage their success on the demand for foreign goods, either imported or exported (Merk, 2013). In particular, according to a neo-classical view, the production activity is organised surrounding efficient ports with the only aim of being closer to the export of manufactured goods or import products and semi-manufactured goods from other countries (Schweizer & Varaiya, 1997). For many years, the political agenda of numerous far-eastern countries has focussed on the level of international trade to boost regional and national economies and make port cities more efficient and attractive for business development. A vast range of policies have been implemented in order to develop port cities, attract investment and support local economic growth. In some instances, these policy tools took the form of special economic zones combined with tax relief and tax breaks for foreign or local investments. A well know example is provided by Free Economic Zone (FEZ): FEZs are specially designed zones which aim to encourage foreign investments by improving the living, management and business environment of the hosting region for foreign-invested firms.

FEZ can be considered the ultimate frontier of market deregulation that creates special districts in order to attract business and thus generate long term growth and economic

benefits. However, when a market suddenly becomes unregulated or liberalised this can be subject to speculative investment triggered by an over-estimation of future economic growth. In these particular cases, speculation tends to affect the real estate market which in port cities tend to be very dynamic.

Speculation acts as a bug into 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, an economy or a region (Bernanke, 1983). Additionally, speculation fuels over-expectations regarding future asset returns, over-heats the investment decisions and turns prices aside from their real fundamental values (Case & Shiller, 2003). In the particular instance of real estate market, speculation refers to the purchase of real estate assets in order to obtain capital gains rather than enjoying the benefits descending from it, thus causing inefficient allocation of the resources and a distortion in level of prices (Kaldor, 1939). Therefore, the speculative drawbacks in port cities can undermine the benefits generated by fiscal policies such as FEZs.

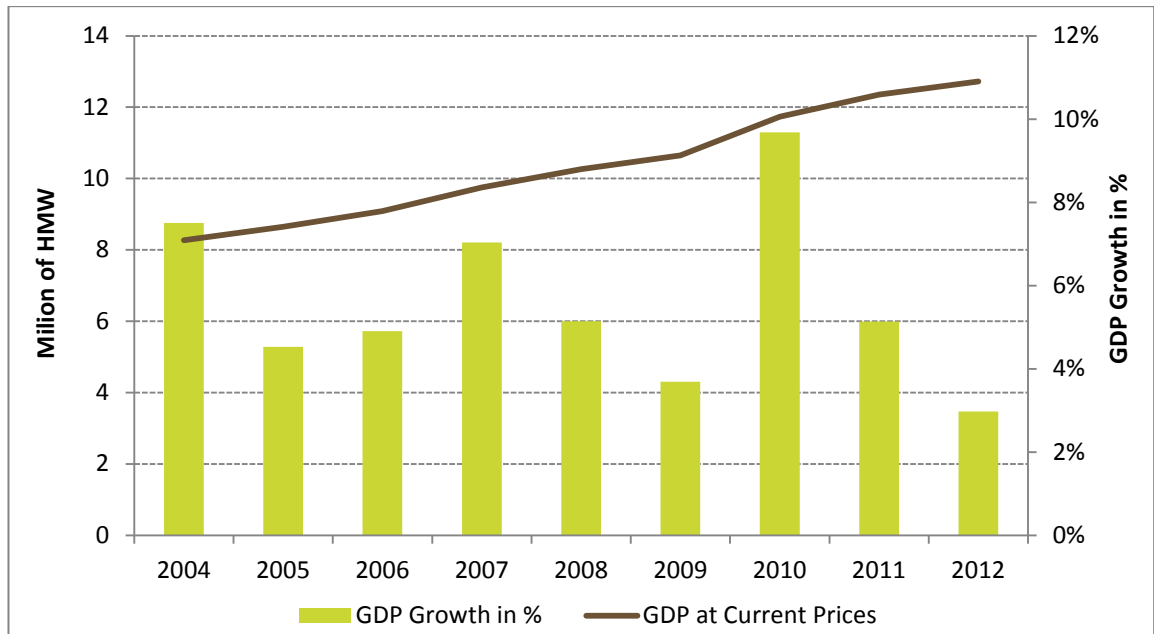
As shown in previous sections, it appears clear that speculation in the maritime industry is brought up by multi-dimensional factors, however there is still no agreement regarding the main determinants and the causality relationships that trigger speculative behaviours at regional level and in particular in port cities and their real estate markets. In fact, speculative behaviours arise from a large spectrum of macro-economic causes and micro-economic interactions; while the macro approach recognises the market inefficiency and monetary conditions (Mises, 2006) as main causes of speculation, a second stream of research emphasises psychological factors and agent expectations as main triggers for boom and bust cycles (Akerlof & Shiller, 2009). Following this view, some economists emphasise the outstanding role of public policies in creating distortions and over-heating the investments in some sectors of the economy.



This is particularly true for the case of South Korea: as Kim and Suh (1993) show, a bubble existed in South Korea from 1974 to 1989 and that was mainly caused by fundamental factors such interest rate and money supply (Lee, 1997). According to this view, the Korean boom and bust cycle was fulfilled by foreign investors attracted by a wide plan of market liberalisations and loose exchange rates policy.

As for other far-east countries, in recent years South Korea has experienced a fast growing economy which poses issues regarding a sustainable long term development, over-heating investment environment and correct pricing of assets. As depicted in Figure 7.1, between 2004 and 2010, South Korea experienced a long period of fast expanding economic growth where the Gross Domestic Product increased by 6% on average. Furthermore, during the global financial meltdown South Korea has over-performed in relation to the other western economies and was able to deliver an outstanding growth pace, mainly driven by its international trade oriented role in the region.

**Figure 7.1** South Korea GDP: real values and % growth. Data Source: South Korean Central Bank.



According to the World Bank, South Korean GDP was US\$1.163 trillion in 2011 and its economy relies deeply on international trade. In 2011, the main economic indicators show that exports accounted for 43.7% of the GDP while the imports were 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 the efficient port activity play a vital role for the South Korean growth objectives.

In order to further revive international trade, boost the level of investments and increase attractiveness to foreign investors, in August 2003, South Korea launched an ambitious program of regional policies which aims at the creation of different Free Economic Zones (FEZs) in particular in port cities. According to South Korea Committee for FEZs, this core set of objectives is achieved by 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 that provide the ground to develop FEZs: Incheon, Busan, Gunsan, Daegu and Ulsan (see Table 7.1).

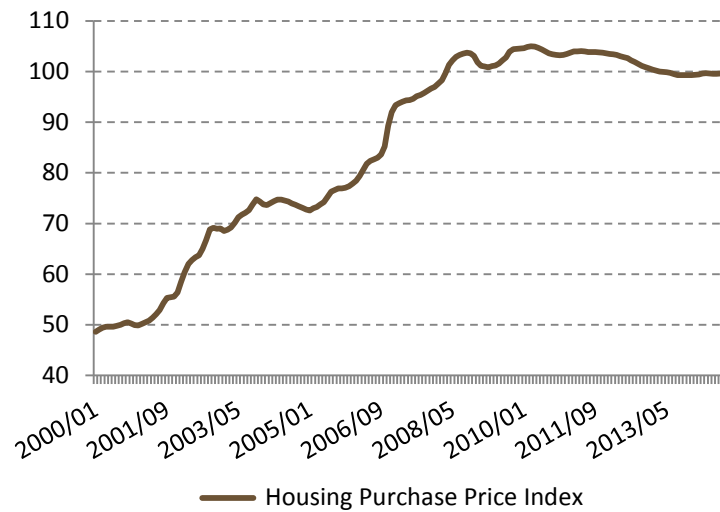
**Table 7.1** FEZs in South Korea. Data Source: fez.go.kr database.

<i>District</i>	<i>Focus Industries</i>	<i>Starting Date</i>
Incheon FEZ	IT, BT, international finance, tourism & leisure	2003
Busan FEZ	maritime logistics, shipbuilding	2004
Gunsan FEZ	automobiles, shipbuilding, green industries	2008
Daegu FEZ	education, medical, knowledge- based	2008
Ulsan FTZ	manufacturing industry (automobiles)	2009

In the past 15 years, the construction and implementation of FEZs have been one of the most outstanding developments in South Korea regional policy: these multidimensional policy tools not only promote foreign investments but bring together a comprehensive plan for revitalisation, redevelopment and refurbishment of urban areas and infrastructures surrounding the FEZ. As an example, Incheon Free Trade Zone, the first FEZ designated area in Korea (August, 2003), on the 169 km<sup>2</sup> area has delivered the redevelopment of Incheon International Airport, Incheon Port, Songdo, Yeongjong, and Cheongna neighbourhoods.

This comprehensive modernisation plan, occurred via FEZ implementation, has triggered a wave of investments in port cities which has particularly targeted real estate assets. Effectively, if at the beginning, the Korean Government selected Incheon FEZ as a global business outpost promoting free economic activities now the plan is developing into the construction of an international urban central hub which poses dramatic impact on the real estate market of the cities. The implementation of FEZ has been followed by a marked and rapid expansion in real estate prices. As shown in Figure 7.2, between 2005 and 2010, the South Korean real estate market peaked and the prices faced a sharp increase that slowed down only after the recession of 2010.

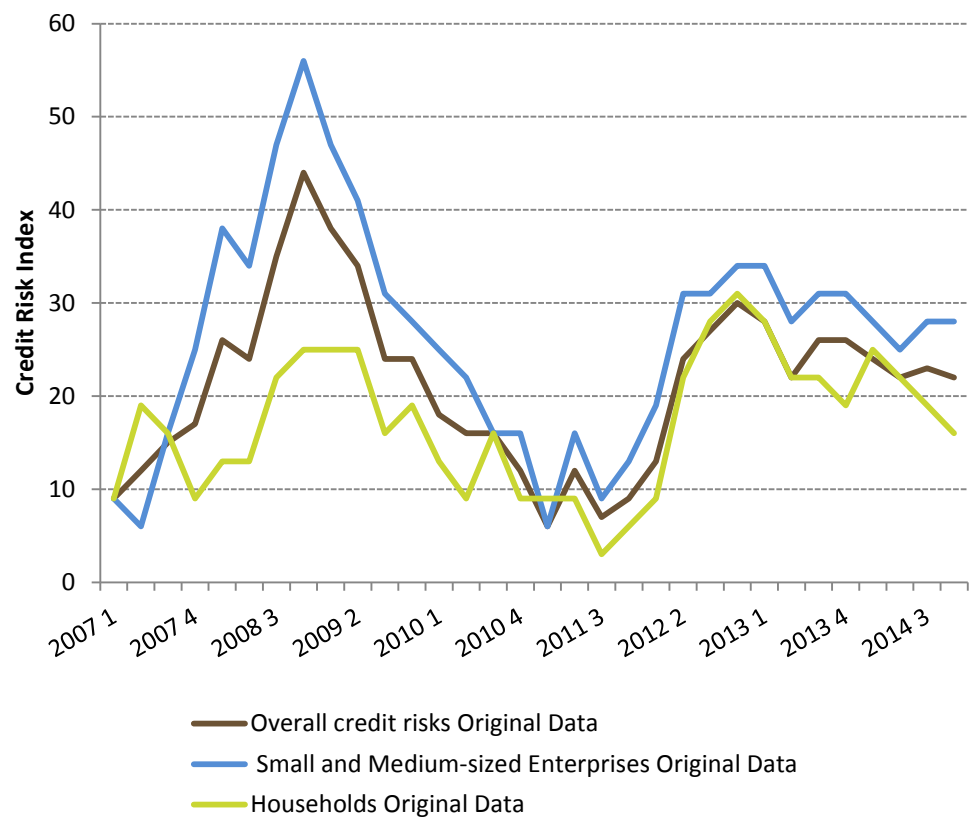
**Figure 7.2** South Korea real estate price index (inflation adjusted). Data Source: South Korean Central Bank.



According to Figure 7.2, South Korean real estate price index experienced a steady growth of more than 5% per year and in the past decades this pattern has assumed the connotation of speculative investments (Ha, 2010). In particular, after FEZ policy has been implemented the real estate prices skyrocketed and in particular between 2005 and 2010 the price growth assumed the connotation of speculative investments. The expectations regarding the success of FEZ policy and the increase in international trade boosted the demand for real estate assets: the level of real estate prices started to increase suddenly as economic agents expected a boost to Korean international trade and business relocation to major port cities. In fact, according to the data provided by the South Korean Central Bank, the house price index dramatically leaped to a 20.8 per cent increase year on year basis. However, the cycle terminated when the global financial crisis bumped into the Korean economy in late 2007. The remarkable real estate price slow-down led to construction companies' bankruptcies and the level of foreclosures resulted in a steep increase of perceived credit risk. As Figure 7.3 shows, the Korean index for credit risk peaked to its maximum level in the first months of 2009 and the main risk factors came not from banking institutions (as in large extent happened in the rest of the world) but from households and small and medium enterprises. The increase in the perception of risk prompted upward interest rates, borrowing costs and contracted refinancing strategies for

borrowers. Therefore, the business cycle contraction has been amplified by the speculation in the real estate market. The boom and bust cycle in the Korean Real Estate Market was more pronounced in the case of FEZ port cities: as the next section shows, the over-expectations created by an increase of international trade and foreign investments prompted a super cycle which was particularly exacerbated in the case of Port Cities hosting a FEZ.

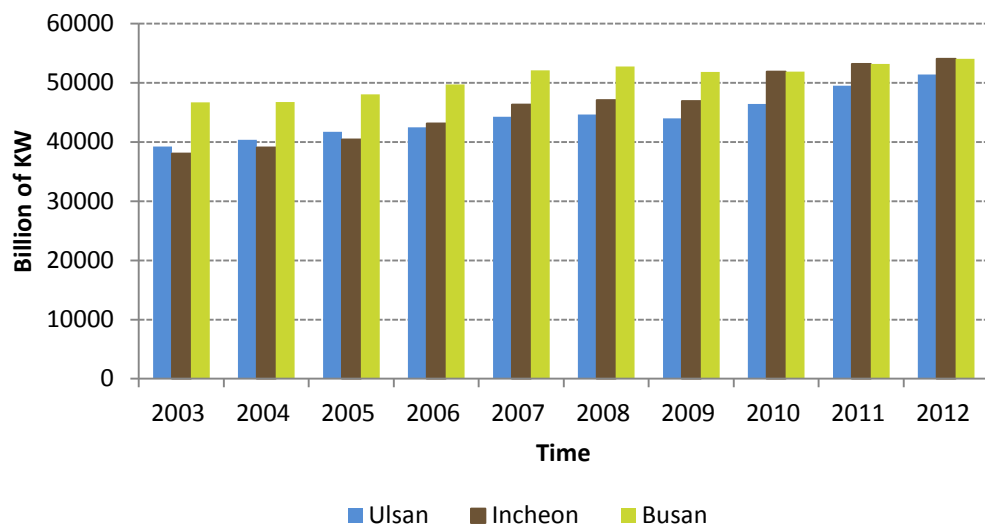
**Figure 7.3** South Korean credit risk index, Data Source: Korean Central Bank.



### 7.3 Case study selection, methodology and data

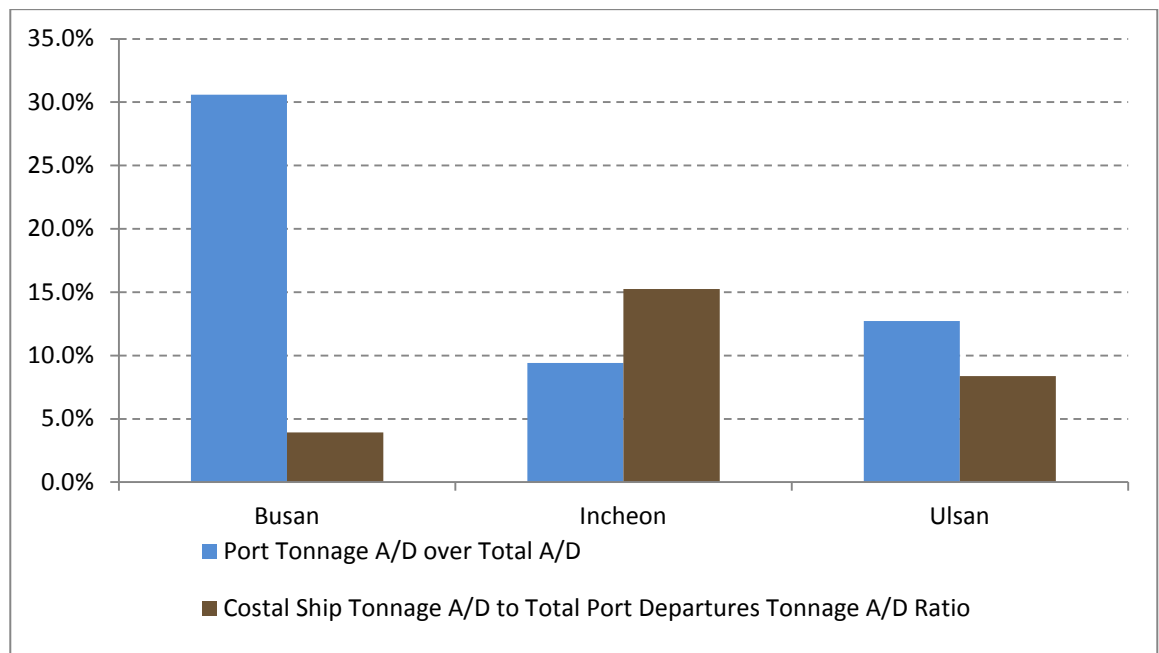
In order to capture the relationship between real estate behaviours and port features, Chapter 7 compares the performance of FEZ ports to their real estate market performances and regional economic indicators of South Korea. The cities included in this research are: Incheon, Ulsan and Busan. Although these cities have the common characteristic of a strong economic expansion between 2004 and 2012, many differences arise upon the productive context and the main features of the local ports. Traditionally, Busan, the largest port city in South Korea, has been an important centre for manufacturing production and exports. After 2008, however, the well-established leadership has been treated by the fast growing cities of Ulsan and Incheon. In particular, between 2003 and 2014, Incheon has risen as a fast expanding city and has bridged the gaps that differentiated it from the other two large port cities (Figure 7.4). This result comes along with the development of a new port and the creation of a new and dynamic FEZ in 2003. The same pattern was experienced in Ulsan: after 2009, year of FEZ inauguration, the city experienced a rapid economic expansion that brought the city GDP very close to the group average after many years of stagnation.

**Figure 7.4** Ulsan, Incheon and Busan GDP. Data Source: South Korea Central Bank database.



Although the cities included in the study share these common economic characteristics, the context of the ports and their own core activities is different: some of them are inherently linked to the productive activities of the inner city, other function as main port for the region whereas the last group of ports serve the interest of the entire country and act as a proper gateway. As a matter of fact, Busan is not only the largest port city in South Korea but also represents a national hub in terms of exports. Additionally, its metropolitan region is considered a prominent cultural, economic and educational centre and it represents a gateway in the whole country (See Figure 7.5). On the other hand, Incheon is the third most populous city in South Korea (after Seoul and Busan) and the city's growth was boosted by the development of a "multi-purpose" port which benefits from its proximity to the South Korean capital. This is particularly true for Incheon: as Figure 7.5 demonstrates, the core activities of the Incheon port focus more on costal shipping than in the other ports included in this study. Finally, Ulsan represents an interesting instance of specialisation: the production context of the city (mainly reliant on the heavy industry) has contributed do further developments and specialization on the city's hinterland and of Ulsan core port activities. It is important to notice that Ulsan is the city where Hyundai Heavy Industries, the largest shipbuilding company worldwide, has it headquarters. Hyundai has developed a long term collaboration with Siemens to provide cutting edge technologies for shipbuilding and has largely invested in the modernisation of Ulsan shipyards and the surrounding port area (Vladimir, 2012).

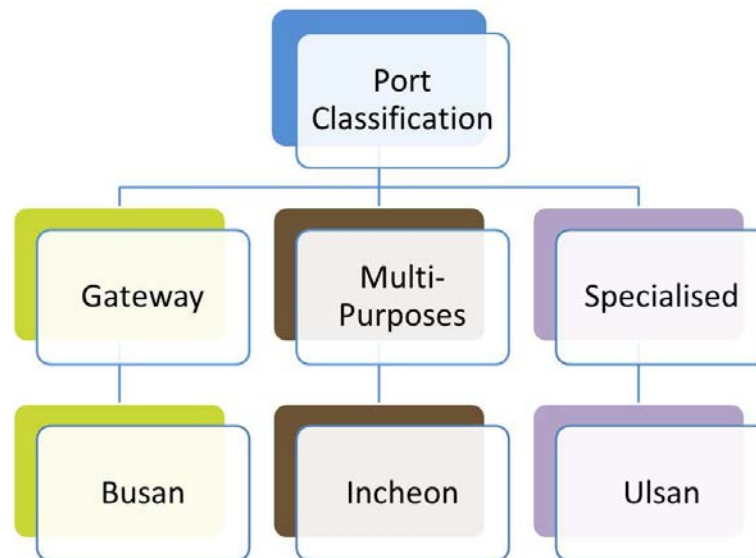
**Figure 7.5** Port Characteristics for Busan, Incheon and Ulsan. Data Source: fez.go.kr database.



Under these circumstances, FEZ cities are characterised as following:

- **Gateway:** are ports inextricably linked to an economic and socially strong territory such as a city ~ *Busan*
- **Multi-Purposes:** are ports in which the main activity is cargo transshipment and are thus almost wholly dependent on relay and feeder activities ~ *Incheon*
- **Specialised:** are ports where the core business relies on the performance of a particular industry located in the city ~ *Ulsan*



**Figure 7.6** South Korean port classification.

Given this selection of case studies, the aims of this study 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 if there is a significant difference in risk perceptions between FEZ real estate performance between gateway, multi-purposes and specialised ports;
3. Verify whether the presence of FEZ creates a leapfrogging effect in the real estate market.

For the purposes of the analysis, two main assumptions are made: first, real estate is considered a perfectly competitive market, with well-informed economic agents who sell and buy real estate assets. Secondly, real estate price fully incorporates the information available in the market. These assumptions are undertaken in order to tackle the problems of liquidity and asymmetry of information which might distort the final conclusions of this Chapter.

Given these assumptions, there are no arbitrage gain possibilities and thus house and the main regional economic variables should follow the same trends.

For the aims of this study, it is collected a dataset that comprises several regional economic variables, city real estate market prices, port characteristics merchandise trading volume per city. The data for the empirical analysis is regional, represents the same unit level (city) and the data sources for the analysis are Korean Central Bank and Real estate Office. According to IMF world economic outlook (2004), the main regional variables linked to the growth in real estate prices are identified and listed in Table 7.2.

**Table 7.2** Key South Korean regional economic variables included in the study.

<b>REGIONAL ECONOMIC</b>	<b>REAL ESTATE</b>	<b>INTERNATIONAL TRADE</b>	<b>PORT</b>
Employment	Land Prices	Total exportations	Number of berths
GDP (real prices)	Commercial Values	Total Importations	Number of TEU traded
Foreign Direct Investments	Residential Values		

The motivation behind the inclusion of these variables in the dataset matches three requirements that are essential for the purposes of this part of the research. First, data reliability which means that there is a certified statistical office that collects these data; secondly, time and space consistency which means that the data has the same sample size and the same collection methodology across the country; and thirdly, availability which means that the data are fully available for all the cities included in our study. Moreover, these variables plays a remarkable role in the identification of economic performance of cities (Spencer, et al., 2009), growth trends in port activity, regional economics (Coppens, et al., 2007) and speculative behaviours (Pan & Wang, 2013). The background of this section shows the multi-dimensional aim of this Chapter: by providing a description of the data, it sheds a light on the economic dynamics of the main cities under scrutiny. Given these foundations, for each objective of the research, the next section

delivers a model regarding speculative investments, tests the variables under scrutiny according to this framework and finally discusses the results of our estimations.

## 7.4 Data analysis and results

Following the model developed in Chapter 4, we readapt the specifications in order to test the system of three hypotheses while, in this instance, house price is defined as a function of the main economic variables of the port city:

$$P_t^* = f(r_t, RF_{t,t-1}^*) \quad 7.1$$

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.

Stiglitz (1990) emphasises 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 doesn’t hold it means that real estate prices are behaving differently from the underlying economic factors and therefore we can assert that a distortion is taking place in the market in the form of speculation.

$$P_t = RF_{t,t-1}^* + B \quad (7.2)$$

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 diverge from its normal growth pace given by the economic fundamentals thus confirming the hypothesis of speculation. In order to test the presence of speculative bubbles in Korean port Cities and differences between port city characteristics, the real estate prices in South Korean cities under scrutiny follow the regional economy fundamental a cointegration analysis is carried out between the house prices and regional factors matrix (Engle & Granger, 1987). The cointegration analysis evaluates whether real estate price and the set of regional economic variables maintain a long-run equilibrium. The two variables are cointegrated if: (I) they are integrated of the same order or: (II) there is a stationary linear combination of the two variables (Johansen, 1995). The basic idea pursued in the analysis is that cointegration test evaluates if the FEZ real estate price component shares the same trend of the other main economic indicator of the region; if this relationship doesn't hold, according to the model, it means that a speculative pricing is affecting the real estate market in the region. In order to provide a more detailed analysis, the capital city of South Korea, Seoul is included in the analysis. This aims to provide a broader picture of the economic situation, compare results with a benchmark and investigate further the pattern unveiled by the empirical tests.

**Table 7.3** Cointegration analysis and test results for South Korean Cities.

City	Testing Variables:	Rank	Lmax test	P-value
<b>Seoul</b> (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]
<b>Incheon</b> (Multi-Purposes 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]
<b>Busan</b> (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	NA	NA
	Real Estate vs City GDP	0	10.597	[0.0785]
		1	1.1696	[0.1795]
<b>Ulsan</b> (Specialised - FEZ)	Real Estate vs Employment	0	16.996	[0.0161]
		1	0.52669	[0.4680]
	Real Estate vs FDI	0	NA	NA
		1	NA	NA
	Real Estate vs City GDP	0	216.26	[0.0000]
		1	13.388	[0.0003]

In Table 7.3, the results of cointegration tests and the p-value statistics are presented for each city under scrutiny. The tests for the city of Ulsan (according to the classification, a specialised port city) show that all the main economic regional indicators are cointegrated with real estate prices; this evidence demonstrates that a specialised port is more connected and linked to the performance of the regional economic system and therefore is less prone to boom and bust cycles. According to this test, the fluctuations in business cycles for specialised 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 groupings of the data which exclude differences at

city level such as, social patterns at council levels, economic growth of the neighbourhoods and market segmentation in the capital city. In fact these patterns are quite spread in large capital cities where a diversified population lives and works: it 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 (multi-purposes port), a significant difference between the growth of the economy and the real estate prices is found. As 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 7.2, the growth in Incheon real estate prices is detached to the other economic fundamentals and in some cases this effect exacerbates fluctuations in business cycle thus leading to speculative investment periods. Additionally, Incheon results are in line with the Seoul analysis: both cities real estate markets developed a different growth pattern between prices and regional economic fundamentals. In the capital city and multi-purpose port city there are driving forces that are pushing the real estate prices away from the regional economic development process. However, if in the Capital Cities social, economic and real estate characteristics can bias the final estimation of the test this is not true for Incheon: the multi-purpose city has a different type of underlying economy leading the changes in real estate market and employment pattern which make it more exposed to business cycle upturns and downturns. In fact, the data analysis suggests that multi-purposes port can experience period of speculation due to their inherent transshipment role: the increase demand from different parts of the country drives up the location attractiveness and generates exuberance in the regional economy thus over-heating the property prices. Following Do (2012), the speculation in the Incheon real estate market poses a remarkable issue for sustainable development of FEZ and Incheon economy. Along with a leveraged real estate market, Incheon speculation drove gentrification in many neighbourhoods of the city: many parts of the city witness a gradual flight of the pre-

existing residents (mostly low-income class) to the nearby vicinities where the land is cheaper (Do, 2010). The significance of these results is confirmed in the second stage of our analysis.

The second step of the analysis focuses on the real estate volatilities in the cities under scrutiny. This second analysis aims to compare the volatilities of real estate prices in order to assess if there is a significant difference in risk between FEZ real estate performances between gateways, multi-purpose and specialised 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 7.4 which shows the critical values and the associated p-value in brackets.

**Table 7.4** Results for ANOVA tests.

F-Statistic (p-value)	SEOUL	INCHEON	BUSAN	ULSAN
<b>SEOUL</b> <i>Capital City</i>	//			
<b>INCHEON</b> <i>Multi-Purposes</i>	319.109 (0.00087)	//		
<b>BUSAN</b> <i>Gateway</i>	306.535 (6.47668E-11)	6.885 (0.031972)	//	
<b>ULSAN</b> <i>Specialised</i>	526.147 (1.66513E-12)	13.698 (0.320405)	3.960 (0.564485)	//

The results show that the city of Ulsan has a different growth pattern in comparison with the other cities. If the variance is used as 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 whilst Incheon presents the higher risk in the data sample under scrutiny. Combined with the former analysis, these results might indicate that a more resilient environment to speculative investments may be found in specialised ports whereas in multi-purposes ports the evidence indicates that a riskier growth and speculative effect

can develop. Nevertheless, it should be emphasised 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 (Malpezzi & Wachter, 2002) thus leading to biased estimations. Overall, it is possible to conclude that although Incheon witnessed a real estate growth detached to the local economic fundamentals, the market presented a higher level of risk which wasn't connected to the nature of the port city itself: the multi-purpose port should be more resilient to economic shocks than specialised ports because the nature of goods delivered are more diversified and thus providing a cushion in periods of economic downturn. This conclusion leads to the possibility that other forces drove 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 provides a safe high return with low variability in downturn the price fluctuations are exacerbated thus leading to higher volatility.

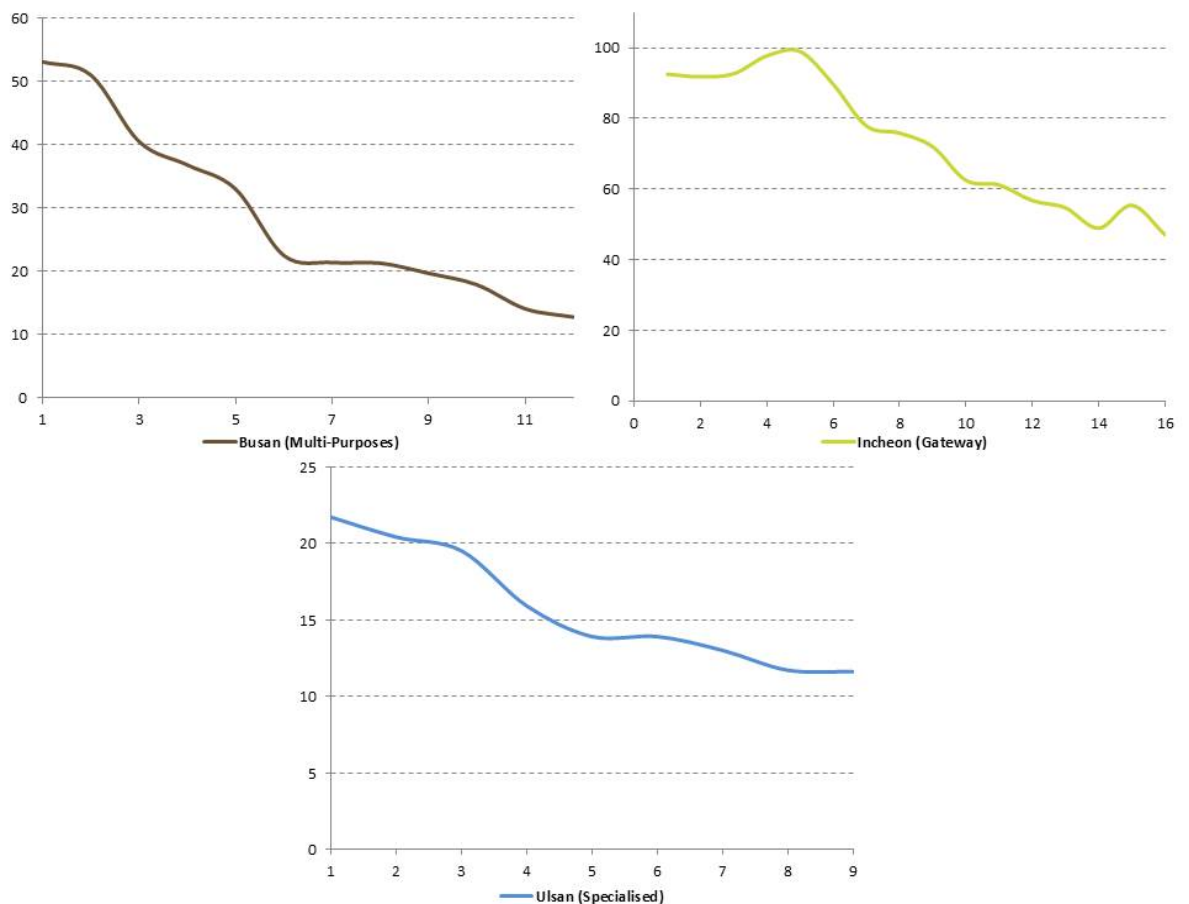
Following the findings of the former tests, there is the need to evaluate the performance of real estate prices in respect to the distance to the Free Economic Zone district. The aim of the third step of the analysis is to verify whether the presence of FEZ creates a leapfrogging effect in the real estate market and obtain a quantitative measure of how prices decay with respect to the FEZ. Leapfrogging effects are development patterns where the urban areas experience jumps in real estate prices, which encourages a non-contiguous city development and potentially causes gentrification, urban sprawl and segregation. In this way, urban policies do not provide a sustainable urban development: when this effect occurs, it is not possible to promote compact and contiguous development patterns that can be efficiently served by public services, regular public service provision across the city and deliver.

The performance of the real estate prices in the districts within each city is evaluated: the first data analysis is provided in Figure 7.5 plots the real estate prices and the relative distance from the Free Economic Zone. At a first sight, the picture unveils different types



of price decay from the FEZ: in the case of Incheon the prices rapidly decay and presents some spikes whereas in the city of Ulsan and Busan prices tend to slowly and constantly decrease with the increase of distance to the FEZ. The peculiar aspects of the picture relate to the jumps witnessed in Incheon where a discontinuity in the decay function provides some interesting pattern of urban sprawl and leapfrogging effects.

**Table 7.5** Real Estate prices ranked according to the distance from FEZ.



As Ulsan shows a smooth and steady decay of prices from the FEZ district whereas Incheon experiences jumps and peaks when prices move away from the FEZ district. While such phenomena can improve the living qualities of the Incheon city, it is the main cause of the gradual flight of the pre-existing residents, whom again are mostly low-income class, to the nearby vicinities where the land is cheaper (“Songdo Development”). Nevertheless, as the pictures above show, there is the need to identify in a quantitative way the effect FEZ distance on prices. These patterns suggest the presence of a

nonlinear relationship between the two that are the variables object of our analysis therefore in order to assess the responsiveness of prices to changes in distances from the FEZ, it is specified a non-linear equation that considers the price decrease as a negative exponential function of the distance to the FEZ district. The equation is in this form:

$$Y_t = A_t X_t^{-\alpha} \varepsilon_t \quad (7.3)$$

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  $t$ ;

$\alpha$  is the parameter that plays the pivotal role in the analysis;

$\varepsilon_t$  is the error term of our model; it is normally distributed and its average equals to zero and has constant variance.

In order to estimate the parameter  $\alpha$ , a nonlinear Ordinary Least Square estimation is carried out. The estimation follows the works developed by Bates and Watts (1988) (Bates & Watts, 2007) and the results of the analysis are provided in Table 7.6.

**Table 7.6** Results of the regressions grouped by city.

	<b>Incheon (Multi-Purposes)</b>	<b>Busan (Gateway)</b>	<b>Ulsan (Specialised)</b>
<b>Constant (P-Value)</b>	4.635 (-9.57E-12)	4.132 (1.09E-10)	3.156 (1.59E-11)
<b>Alpha (P-Value)</b>	-0.033 (0.011)	-0.139 (1.05E-05)	-0.085 (1.05E-05)
<b>R-Squared</b>	0.62	0.94	0.95
<b>S.E. of Regression</b>	0.076	0.096	0.056

The results of the non-linear regression show that Incheon alpha parameter is negative and is the smaller between the samples under scrutiny. In Incheon, results show that there is a high negative dependency of prices in relation to the distance from the Free Economic Zone. Yet, given this parameter, the fastest growing FEZ districts in Incheon are also districts that increase their importance within the city network and will create a predominance that carries out a larger level of inequalities within city boundaries. The opposite situation is verified in Ulsan and Busan where the parameters are larger and indicates a higher elasticity of prices with respect to the FEZ distance. The fact that the parameters diverge so much brings further attention to the speculative issue: to some extent we consider that resiliency to speculation is nested inside more flexibility. In the extent to which a price buffer provides more opportunity to escape from sudden supply and demand changes it is less likely to witness speculative patterns and boom and bust cycles.

## 7.5 Results discussion and conclusions

The dataset employed in the research consists of a vast and multidimensional collection of economic and financial variables gathered from South Korean real estate authorities, South Korean Central bank and statistic office. The period investigated ranges from May 2003 to December 2013, yielding a total of 400 observations. Given the lack of study regarding port characteristics and real estate speculative investments, in Chapter 7 the monthly dataset was used extensively in order to test the following three steps analysis: 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 is a significant difference in risk perceptions between FEZ real estate performance for the gateway, multi-purposes and specialised ports; and third, whether the presence of FEZ creates a leapfrogging effect in the real estate market.

The analysis was based on three econometric and statistical test: in the first part of the analysis the cointegration between real estate prices in the gateway was tested, specialised and multi-proposes ports with main economic regional variables; in the second analysis, a test on the variance was employed in order to compare whether or not the real estate market risk was significantly different between the cities under scrutiny; finally, the third part of the analysis used a non-linear regression in order to verify different decay functions in South Korean Port cities.

The main results are summarised as following: the presence of speculative bubbles was tested within the cities of Seoul, Busan, Ulsan and Incheon. The results suggested the presence of speculative behaviours in particular in the cities of Seoul and Incheon (Multi-Purposes port). The test of the variance within real estate prices of the cities indicated that Incheon real estate price volatility was significantly higher during the period under scrutiny and showed that only the city of Ulsan developed a more resilient price growth. In the last step of the analysis, the decay function of prices from the FEZ district analysis provided further evidence regarding the different behaviours of port city real estate market: first of

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all, Incheon developed an irregular pattern of real estate prices and raised concerns regarding leap-frogging effects. Second, the elasticity of price changes was quantified to the FEZ distance: the city of Ulsan showed a less steep decline from the FEZ district and provided more evidence regarding a harmonious development of real estate prices.

The results obtained in Chapter 7 trigger interesting policy discussions on regional economic growth management. This study confirmed the presence of speculative behaviours in South Korea and FEZ cities. In particular, speculative effects are likely to happen when the FEZ is connected to a multi-purpose port such as in the case of Incheon. Korean regulation for speculation has not considerably enhanced real estate stability and that FEZ policy has major effect on real estate where ports are specialised. It is possible to conclude that FEZ plays a pivotal role (dynamo effect) for local development by enhancing regional attractiveness, competitiveness and agglomeration; nevertheless, since speculation undermines the regional benefits brought up from the implementation of Free Economic Zone in order to achieve integral results, FEZs should be tailored upon the characteristics of the port area.

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## Chapter 8 Conclusions

### 8.1 Conclusion

Detecting speculative behaviours and managing risks in the dry bulk shipping industry is a complex research field: it involves the understanding of multi-dimensional effects and interdependencies between the variables under investigation. From the elementary relationship between business cycles and freight rates, many complicated theories and models have been developed to describe common phenomena such as investment cycles, regional economic dynamics and international trade patterns. However, managing speculative risks in boom and bust cycles remains a formidable challenge for both ship-owners and policy makers due to the vast array of factors influencing the demand for dry bulk cargo. In the aftermath of the 1997 - 2010 speculative trends, there is a need to extend the discussion to industries that are less involved in the actions undertaken by financial bodies to curtail the negative effects of boom and bust cycles.

By promoting the debate on the negative effects of speculation in the maritime industry, this thesis sheds a light on the factors and the main determinants of speculative bubbles in the dry bulk industry. In doing so, the analysis provided a comprehensive set of tools that allow policy makers, ship-owners and investors to effectively manage and mitigate the effects of boom and bust cycles on the normal functioning of the whole industry. Following the four research questions put forward in Chapter 1, the thesis tackled the speculative problem in the dry bulk industry by implementing an organic step-forward analysis. Each Chapter answers a single question and proposes a challenge that is addressed in the following piece of research. Owing to this approach, it was possible to first, comprehensively evaluate the multi-dimensional causes and effects of speculative cycles

in the dry bulk industry. Secondly, to provide an in-depth and tailored analysis. In fact, in order to respond to the industry needs, each Chapter addresses a research objective and further broke it down in to a sub-set of more specific questions. In doing so, the functions of the Thesis' chapters are threefold: first, identify the key issues behind the research question and define the investigation plan. Secondly, establish a rigorous and robust methodology that underpins the quantitative analysis of the problems. Thirdly, from the result obtained communicate risk management insight and propose policy recommendations. According to this framework, Table 8.1 summarises the research questions, approach, findings and impacts at risk management and policy levels.

**Table 8.1** Research approach summary: questions, methodologies, results and impacts

	<b>Research Questions</b>	<b>Methodology</b>	<b>Research Results</b>	<b>Risk Management and Policy Recommendations</b>	<b>Chapter</b>
1	Did the dry bulk market witness speculative effects in recent years and to what extent did these effects influence levels of investment?	Multi Factor Global Model to evaluate the behaviour of Dry Bulk Freight Rates and Cargo Prices	Between 2005 and 2010, the Dry Bulk Freight Rates witnessed a speculative cycle	A comprehensive macro-economic factor analysis contributes not only to the monitoring of dry bulk risks but also reveals period of excessive investments in new cargoes	4
2	Did the speculative effects spill over to maritime industry from other financial markets?	The Cointegration and VECM Methodologies study the spillover effects between Commodity markets and Dry Bulk freight rates	Part of the Dry Bulk Speculation was driven by a super-cycle in the commodity markets	A rigorous risk management process and discipline should be implemented in order to prevent the negative effects of market spillovers from the commodity markets	5
3	Which are the main determinants that can influence the level of freight rates? Are there different vessel, commodity and structural factors that create over expectations in the market?	The Micro Economic evaluation of Freight Rates determinants uses the Two Stages Least Square and Heckman Models	The Speculative Cycle has redefined Investment Preferences and Contracting features of Ship-Owners and Charters	An in-depth analysis of Freight Rate cycle should be carried out before triggering major investment plans, in particular at port level	6
4	Does structural factor of maritime industry spill over to other connected market such as real estate property in port cities?	The linear and non-linear models investigate real estate dynamics in port cities that implement Free Economic Zone policies	The effect of maritime speculation can be transmitted from port activities to the regional real estate market and undermine regional economic policies	In order to achieve integral results, Free Economic Zone policies should be tailored upon the characteristics of the port area	7



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More precisely, in Chapter 2 and Chapter 3 it was shown that, in the context of a world growing ever smaller, the Chinese market liberalisations (post 2000, joining WTO) and commodity market financialization had a major impact on international trade dynamics and raw material prices. The time line of these events was concomitant to a sudden shift in dry bulk cargo demand and as proved in Chapter 4 the sharp increase in dry cargo demand led to a boom and bust cycle in the market characterised by short term speculative investments. As a matter of fact, the speculative behaviour was not self-generated but was triggered by commodity price dynamics and Chapter 5 provided a quantitative assessment of the speculative market spillover from commodities. Nonetheless, as shown in Chapter 6, this speculative spillover shouldn't be considered as a standalone effect but needs to be contextualised in a multidimensional and dynamic framework which delivers major impacts on ship-owners investment decisions and freight laycan periods: the evaluation of micro economic determinants has proven that ship-owners consider the level of freight rates in order to determine port investments, fleet renewal and laycan periods thus leading to a transmission of speculative behaviour into the final dry bulk industry stability. Additionally, it was demonstrated that the dry bulk market leverages over the main regional dynamics: the industry is not only linked to the performance of the overall business cycle but is able to exploit regional dislocations and global economic imbalances. As shown in Chapter 7, these characteristics are exacerbated by international trade policies: in the case of Korean Port Cities, port investments and regional policies influenced the state of the local economy and could potentially lead to real estate super cycles. This chapter proves the major role played by the maritime industry in developing investment cycles, not only in the sea but on land too.

## 8.2 Did the dry bulk market witness speculative effects in recent years?

As shown in Chapters 2 and Chapter 3, the process of market liberalisation in China twinned with the financialisation of commodity markets prompted a super cycle in the price of raw materials between 2005 and 2010. In the same period, the dry bulk industry witnessed a boom and bust phase. During this boom and bust phase, many concerns were raised over the stability of the industry and whether or not the Dry Bulk freight rates were exposed to speculative effects. The aim of Chapter 4 was to assess whether the boom and bust cycle was driven by speculation or was a supply and demand outcome. In order to evaluate the presence of speculation, firstly a theoretical model was used to explain the relationship between Cargo Prices and Freight rates. Secondly, a global multi-factor risk model was implemented to estimate the long term (cointegration) relationship between freight rates and cargo prices. Thirdly, ADF and Cointegration tests were performed in order to evaluate the presence of speculative bubbles in the dry bulk market.

In Chapter 4, an extensive dataset was collected to account for the key variables in the dry bulk industry, namely the freight rates (Baltic Dry Index, “BDI”) and the cost of purchasing a new cargo (Bulk Dry Cargo Selling Price Index). Additionally, in order to estimate the changes in the covariance matrix, the four major global market indices were collected: Global Equity prices (MSCI World), Global Bond Prices (JP Morgan Global Bond Index), Global Commodity Prices Index (S&P - SPGSCI), Trade Weighted U.S. Dollar Index (USDTW).

The empirical results obtained in Chapter 4 suggested that a speculative period took place in the dry bulk industry between 2005 and 2010. In particular, both tests (ADF and Cointegration) applied to verify the long term relationships between Freight and Cargo Prices failed to confirm that the two variables followed the same trend in the period under investigation. Although some differences in liquidity and market segmentation might distort the picture provided by the data, it was emphasised that the two variables significantly

started to experience different levels of variability. In particular, with the help of the factor model, it was shown that the factors contributed roughly in the same proportion to the total variations in both BDI and Cargo Prices. However, it was noted that the main risk contributions are provided by Commodity Prices and Equity Market exposures. A possible explanation for this risk pattern was given by the boom and bust cycle witnessed by the commodity markets during the same period. In fact, in the back-testing phase, it was shown that equity (MSCI) and commodities (SPGSCI) forces became the main driving factors in determining freight rate trends, in particular after 2005.

### ***Future Works***

In order to comprehensively describe the market changes caused by speculation, this framework should be move from a static to dynamic framework; in doing so, it will be possible to test ex-ante test the presence of speculative bubbles. However, the problem with the dynamic specification is that given the structure of financial time series, auto-correlated and showing clustering of periods characterised by high degrees of volatility followed by low volatility periods it could lead to bias estimations of the model coefficients. If factor returns were uncorrelated across time, the methodology used in this chapter is sufficient for modelling freight rates and cargo prices. However, although the assumption of serial independence for returns is consistent for longer horizons, this doesn't hold for short term asset returns. Over short time frames, market microstructure tends to develop sort of "*momentum*" relationships that induce autocorrelation in the returns. In order to overcome, the financial literature have developed models that reduce these drawbacks, among others it is important to cite GARCH/ARCH models (Engle, 1995), Newey West Methodology to estimate robustly the covariance matrix in presence of serial autocorrelation (Newey & West, 1987) exponential weighted moving average to correct for long time series memory (Lucas & Saccucci, 1990).

***Risk management and policy recommendations.***

The results obtained in Chapter 4 suggest that freight rates became more exposed to equity risk factors and involves a more aggressive and volatile market place where sudden spikes and momentum changes turn the level of freight rates from booms to busts. Ultimately, the speculative period has created a more nervous market, vulnerable to reversals and stiffer shock absorption. This effect was particularly strong with regards to the commodity market: as shown in the back testing phase, between 2005 and 2010, the sensitivity of freight rate to commodity was the highest indicating a potential contagious effect from the commodity super-cycle. This result prompted the research carried out in Chapter 6.

**8.3 Did the speculative effects spill over to the maritime industry from other financial markets?**

In Chapter 6, a Vector Error Correction Model analysis was conducted in order to evaluate whether or not speculative effects were transmitted from commodity market to dry bulk freight rates. The background was provided by the findings in Chapter 5 and the boom and bust cycle on commodity markets between 2005 and 2010. Based on a weekly time series of wheat price and dry bulk freight rate, the main economic characteristics elapsing between these two markets were identified in two stages. First, the statistical tests (Dickey-Fuller and Cointegration) confirmed a cointegration relationship between wheat market price and freight rate. The numerical results showed how wheat price and freight rate effectively share a common trend.

Second, by implementing a Vector Error Correction (VEC) model, it was demonstrated that oil shocks have a positive impact on freight price, but that wheat price shocks also induce large changes to the freight rate dynamics. These results are significant for the dry bulk industry indicating that the price of wheat may face an upward trend due to a shock

(i.e. speculative investments), and this in turn can stimulate a rise in the dry bulk freight rate.

Since the elasticity coefficient of wheat and oil are significant, it was proven that speculative commodity markets may affect freight rates positively. In light of these results, it is observed that a prolonged period of over-liquidity and speculation in commodity markets, due to institutional investors, can cause a steep increase in wheat prices. In particular, the presence can alter the pricing dynamics of agricultural commodities thus exacerbating prices swings and volatility clusters.

Moreover, speculation in commodity markets can threaten the stability of freight rates and therefore causes cascading effects in a way that biases not only the efficient pricing but leads to a distortion in investment and consumption decisions. Shocks to wheat price may move over freight rates and lead to higher profits, over-expectations in the dry bulk industry, and therefore inflates investment decisions (such as fleet investment).

### ***Future Works***

The primary objective of this Chapter was to evaluate the cointegration of wheat and freight rates in a particular period of time (the boom and bust period between 2006 and 2011). The selection of this time frame where the variables under scrutiny experienced a unique boom and bust cycle might affect the final coefficient estimations. Therefore, it is recommended to further back-test the final results by investigating the price elasticity of Oil, Freight and Wheat over different time samples. Checking the presence of structural breaks and sudden shifts in the Data Generation Process will further enhance the robustness of the analysis and might lead to new scenarios and policy recommendations.

### ***Risk management and policy recommendations.***

The results provide notable policy recommendations by showing that speculation effects spillover from wheat markets to dry bulk freight rate. However, the analysis has mainly focussed on a particular route therefore the result of the analysis should be applicable to

the context of both very liquid commodity contracts (Wheat) and very liquid freight rate markets (route North West Pacific). The possibility of extending the analysis to less liquid markets should be taken into account in order to enhance the strengths of the policy recommendations. However, the problem related to less liquid markets is that prices are more volatile, less accurate and are characterised by sharp changes in seasonal patterns: in this context, statistical inference is an extraordinary challenge that might provide inconsistent estimations.

#### **8.4 Which are the main determinants that can influence the level of freight rates in speculative periods?**

Following the results obtained in previous chapters, Chapter 6 concentrated on the study of the micro-economic impacts of speculative behaviours in the dry bulk industry. In particular the objective was to evaluate whether the speculation in the dry bulk shipping market can be transmitted to ship-owner investment decisions and in particular if this can affect port infrastructures and contracting of dry bulk fixtures.

In doing so, a Two Stage Least Square analysis and back-testing of the empirical results was provided in order to investigate broadly the effects of structural port factors, iron ore prices and maritime specific factors on the level of freight rates. The research results of Chapter 6 proved that iron ore freight rates are influenced at the micro economic level by the structural characteristics of ports' iron ore terminals and iron ore market factors. In addition, a significant relationship between cargo features and the level of freight rates was found; in particular, the results obtained from the Heckman model suggested that cargo size plays a remarkable role in the estimation of the coefficients. It is possible to draw four main conclusions from this analysis. First, port infrastructures and iron ore terminals have a direct impact on the laycan period and time elapsing between arrival and loading of iron ore cargoes. The number of available berths, ship length, and ship-loader productivity significantly diminish the laycan periods, thus decreasing time cost for charters and ship-owners. Second, the maritime-specific factors still have the major

responsibility in determining the level of freight rates: nautical distance, cargo size, volatility, and laycan period play a pivotal role in the bargaining process of the iron ore voyage freight contract. Third, there is a consistent regional effect and iron ore industrial structure influencing freight rates: Brazil and its main mining company, Vale, pays higher voyage freight rates in comparison to Australia and its largest company, Rio Tinto. This effect has triggered a recent massive investment plan in which Vale buys very large iron ore cargoes and enters into long-term chartering agreements in order to stay competitive in the world's iron ore market.

Fourth, through an application of the Heckman model, it is shown how cargo size plays a significant role in the iron ore dry bulk industry: vessels employed for iron ore trading are suitable for large long haul distances; the findings of this study are therefore not applicable to smaller vessels. However, the conclusions drawn from the analysis can be applied to iron ore freight rates only. In the case of grain trading, which generally relies on dry bulk cargoes of minor sizes, further analyses should be performed.

### ***Future Works***

This Chapter evaluated the micro-economic determinants of and Dry Bulk freight rates by modelling structural and specific factors. The data sample was restricted to the years 2012 to 2015 for a lack of port infrastructure data prior to 2012. Although this Chapter provides interesting results from a policy and risk management perspective, it is recommended to extend the modelling part to the years prior to 2012. This objective can be achieved by designing a data collection at port level by engaging with port authorities in the main global iron ore hub. In doing so, it would be possible to comprehensively evaluate the changes caused by the boom and bust cycle on the Maritime industry, both at port level and cargo level. In addition the analysis allows to investigate the impact of infrastructure and technologies in reshaping the dry bulk sector and regional dynamics.

***Risk management and policy recommendations.***

The findings of Chapter 6 prompt different risk management recommendations: first, if a speculative period takes place in the Dry Bulk industry this effect can be transferred to investment decisions at port level. The relevant role played by the interaction of freight rates and port infrastructures can trigger periods of over-investment in ports when freight rates experience periods of boom. In periods of boom and bust cycles port investments might be allocated towards short-term speculative trends that are not profitable in the long run thus leading to an unsustainable port development. The same argument applies to fleet renewal: in periods of boom, when earnings are strong, ship-owners might decide to over-invest in new cargoes with an expectation of a prolonged period of profitable freight rates revenues. However, when the boom cycle ends, it is possible that ship-owners are not able to service the debt taken to pay for the new cargo which can consequently lead them to going bankrupt and exiting the industry.

Second, laycan periods are affected by the level of freight rates: timing for port arrival can be influenced in periods of boom and bust leading to congestions at port level and over-deployment of cargoes in some area of the globe. However, it should be recognised that this estimation could be potentially biased by the actual demand for cargoes in some regions of the world: as in the case of Far-East Asia, the recent international trade pattern creates a huge demand for dry bulk cargoes therefore the supply of vessel is concentrated in this region of the world. As shown by the Regional and Market Models, the shipping market is shaped by the state of the iron ore industry and its geographical positioning.

**8.5 Do structural factors of the maritime industry spill over to other connected markets such as real estate property in port cities?**

As seen in previous chapters, the dry bulk industry is prone to boom and bust cycles that turned into speculative phases in periods of excessive market exuberance. Additionally, it



has been shown that these speculative effects shouldn't be treated as isolated industrial phenomenon but contextualised in a multidimensional framework. The interrelations between commodity markets and freight rates leads to market spillovers hence, speculation can be transmitted from one market to another. As concluded in Chapter 6, the important role played by freight rates in leading the industry investment decision has an effect on regional dynamics thus spreading speculative periods to regional economies. As a port connects the sea with the inland it is the unique gateway where speculative effects can move from the dry bulk industry to the regional economy. However, these speculative patterns can be addressed by policy makers. In recent years, in order to attract investments and trade, Free Economic Zone policies have been implemented in Far East Asia ports.

Given this background, Chapter 6 studied real estate speculation in Free Economic Zone (FEZ) port areas. For port development, FEZs are effective policy tools which foster regional economic performance, attract new business activities and investments to the cities. Nevertheless, the regional benefits generated by port developments and FEZ can be undermined by investors exuberance regarding the future performance of the economy and real estate speculation. The dataset employed in this part of the analysis consisted of a vast and multidimensional collection of economic and financial variables gathered from South Korean real estate authorities, South Korean Central bank and statistic office. The period investigated ranges from May 2003 to December 2013, yielding a total of 400 observations.

Given the lack of study regarding port characteristics and real estate speculative investments, in Chapter 7 was sliced and diced the extensive monthly dataset in order to test the following three steps analysis: first, it was evaluated whether or not the performance of real estate market is in line with the main economic indicators of city economy. Secondly, it was assessed if there is a significant difference in risk perception between FEZ real estate performances in gateway, multi-purposes and specialised ports.

And thirdly, it was verified whether the presence of FEZ creates a leapfrogging effect in the real estate market.

The analysis was based on three econometric and statistical tests: in the first part of the analysis, the cointegration between real estate prices in gateway, specialised and multi-proposes ports with main economic regional variables was tested. In the second analysis, a test on the variance was carried out in order to compare whether or not the real estate market risk was significantly different between the cities under scrutiny; finally in the third analysis, a non-linear regression was employed with the purpose of verifying different decay functions in South Korean Port cities.

The main results are summarised as following: the occurrence of speculative bubbles within the cities of Seoul, Busan, Ulsan and Incheon was investigated. The presence of speculative behaviours was confirmed in particular in the cities of Seoul and Incheon (Multi-Purposes port). The test of the variance within real estate prices of the cities confirmed that Incheon real estate price volatility was significantly higher during the period under scrutiny and indicated that only the city of Ulsan developed a more resilient price growth. In the last step of the analysis, the decay function of prices from the FEZ district analysis provided further evidence regarding the different behaviours of port city real estate market: first of all it was noticed that Incheon developed an irregular pattern of real estate prices and raised concerns regarding leap-frogging effects. Secondly, the elasticity of price changes to the FEZ distance was quantified: the city of Ulsan showed a less steep decline than the FEZ district and provided more evidence regarding a harmonious development of real estate prices.

### ***Future Works***

The step forward analysis developed in this Chapter provides the fertile grounds to test how port policies influence the real estate market and port structures. In order to achieve a comprehensive understanding of forces and mechanisms affecting these key regional

variables it is suggested to carry out an impact evaluation which attributes the impact to policies and projects. In doing so, it is recommended to extend these analyses to different case studies at global level: first, it would be useful to compare the extent to which FEZs, real estate and ports behave in other part of the world. Secondly, it would be beneficial to test what happens in situations where the port is expanding but no FEZ policy is applied. Having a broad and diversified comparison group will strengthen the results obtained in this Chapter and it will provide a useful benchmark to read these results under different perspectives.

### ***Risk management and policy recommendations.***

The results obtained in the analysis triggers interesting policy discussions on regional economic growth management. Chapter 7 confirmed the presence of speculative behaviours in South Korea and FEZ cities. In particular, speculative effects are likely to happen when the FEZ is connected to a Multi-Purposes port such as in the case of Incheon. As Chapter 7 showed, Korean regulation designed to curb speculation did not considerably enhanced real estate stability and that FEZ policy has major effect on real estate where ports are specialised. Therefore, it is possible to conclude that FEZ plays a pivotal role (dynamo effect) for local development by enhancing regional attractiveness, competitiveness and agglomeration. Nevertheless, since speculation undermines the regional benefits brought about by the implementation of Free Economic Zone, it can be argued that in order to achieve integral results, FEZs should be tailored depending on the characteristics of the port area.

## **8.6 Conclusions and future works**

Detecting and effectively managing speculative risks in the dry bulk industry is a complex research field. In order to provide efficient models and practical conclusions, it is necessary to evaluate the complex system of variables affecting the performance of the dry bulk industry as a whole. This involves the usage of extensive datasets that are able

to capture micro-economic and macro-economic interactions affecting the dry bulk industry. The vast array of relationships spans from global business cycle, commodity markets and international trade dynamics to regional factors, ship-owners investment decisions and port locations. Although, the level of sophistication in modelling is very high it might be biased by causality, non-linear interactions and simultaneous relationships. In this context, the works presented in this thesis can be extended in three main strands of research:

1. Fully evaluate the relationship of commodity markets with dry bulk freight rates with a particular focus on modelling simultaneous changes in the level of both markets;
2. Further investigate the relationship between laycan periods and regional economic growth in order to comprehensively account for macro-economic trends affecting the micro-economic estimations;
3. Extend the port city analysis to other circumstances and verify whether or not the multi-purposes port are more prone to boom and bust cycles in general or is this just the effect of the implementation of FEZ in Korea.

Moreover, additional analyses are required to evaluate the structure of dry bulk market in the periods pre-crisis and after crisis. It is recommended to further evaluate how the boom and bust cycle has reshaped not only the structure of the industry itself but has affected the regional markets. This can be achieved by a sensitivity analysis of the change in structural coefficients of the regression over time and in particular between the periods investigated in this thesis.

In conclusion, starting from the boom and bust period in dry bulk and commodity markets, the present research conceptualised a framework to detect and manage the risk of speculative cycles in maritime industry. This framework has been defined analytically using the economic theory, rigorously implemented in statistical models and tested by using

different econometric techniques. The major results presented herein contribute to the understanding of speculative risk with a particular focus on the maritime industry. These results should foster a constructive debate on managing speculative behaviours in order to improve the efficiency of the maritime industry.

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