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Estimating the Effects of Containerisation on World Trade

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Abstract

This thesis examines the effects that containerisation had on the growth in world trade between the years 1962 and 1990. Containerisation is a technological change that arises from shipping goods via containers rather than through the traditional break-bulk method which characterised international shipping since antiquity. This thesis makes many contributions to the literature. This is the first quantitative and econometric study into the effects of containerisation in economics. We collect data from a specialist business publication and construct container variables which are used for the first time in economics. We also use a scientific classification from 1968 to classify products as containerisable or non-containerisable. Another contribution is that the econometric models employed in this thesis allow for a "horse race" between the technology variable and the policy variables: free trade agreements, General Agreement on Tariffs and Trade (GATT) membership and currency unions. We make use of the cross-sectional and time series variation available to us in the adoption of the technology across 157 countries to identify the effects of containerisation on world trade. We employ several specifications and try different trade flow dimensions to pin down the right way to model containerisation. In doing so, we deal with several econometric problems that arise in similar econometric studies such as omitted variable bias and endogeneity bias. The effects of containerisation are felt 10 to 15 years after bilateral adoption of the technology. We estimate that containerisation led to an increase of 380% in North-North containerisable trade 10 to 15 years later. We find no evidence for endogeneity in this specification and we can be confident to make a causal statement. We also find evidence that containerisation affected North-South trade the most, followed by North-North and then South-South containerisable trade although we cannot be as confident about making causal statements in the case of North-South and South-South trade. The evidence is however suggestive of strong effects on containerisable trade in the two subsamples. In all cases, the effects of containerisable are found to be multiple times the size of the effects of the individual policy variables - 2 to 10 times as large depending on the subsample and the variable in question.

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Chapter 1

Introduction

"Born of the need to reduce labour, time and handling, containerisation links the manufacturer or producer with the ultimate consumer or customer. By eliminating as many as 12 separate handlings, containers minimise cargo loss or damage; speed delivery; reduce overall expenditure"[1]

After World War II, world trade has grown to unprecedented levels. This is sometimes referred to as the second era of globalisation. Between 1948 and 1993, world trade has grown by an average of 150% annually in nominal terms. In real terms, world trade has grown by an average of around 21% annually between 1962 and 1990. According to Krugman (1995), economists and journalists have differed in opinion as to why trade has grown so much. The first group relate this growth mainly to bilateral and multilateral trade liberalisations while the second group maintains that it was led by technological advances in transport, logistics, and communication. Many economic studies have emphasized the role of trade liberalisation in advancing world trade and globalisation. While many other studies explored the effects of the switch from sail to steam and the introduction of the railway/steam train in the first globalisation era, very few economics studies exist that look at the role of technological progress in the second globalisation era which is characterised by the introduction of the container in shipping in the 1960s and 1970s and cheap air cargo in the 1990s.

This PhD thesis examines the effects that containerisation had on the growth in world trade. Containerisation is a technological change that arises from shipping goods via containers rather than through the traditional break-bulk method which characterised

[1] Containerisation International Yearbook 1970, page 19

international shipping since antiquity. This thesis makes a few contributions. Although there is plenty of qualitative and case study evidence suggesting that containerisation stimulated international trade, we are not aware of any direct quantitative evidence of the effects of containerisation on world trade. This is the first attempt to study the effects of containerisation on international trade quantitatively and econometrically.

The few studies that aim to quantify the effects of containerisation have primarily focused on the effects of port-to-port transportation costs after countries' adoption of container technology. However, the transportation literature stresses that the main resource savings from containerisation stem from the container-induced overhaul of the transportation system that eliminated as many as a dozen different handlings and linked the producer more directly with the customer. There are qualitative aspects of containerisation - like the creation of new container ports- that the above-mentioned studies do not capture. Other aspects include time savings, volume effects (scale), the reduction of pilferage, port efficiencies, and reduction in labour union powers, and the induction of the hub and spoke systems.

The subject of this research lies at the crossroads of two major streams of research. One delves into the impacts of changes in transportation technology. Containerisation is actually only one of many technological changes that have hit the shipping industry in the past two centuries. The switch from sail to steam in the 19th century (Harley (1973)) coupled with the proliferation of railways (Hurd (1975)) led to radical changes in the industry. The resulting decline in freight rates encouraged significant increases in world trade (Mohammed and Williamson (2003)). This research investigates whether containerisation had a similar impact on trade. Evidence of a similar decline in freight rates after World War II (WWII) seems to be lacking. Some scholars doubt that ocean freight costs have fallen very much since the middle of the twentieth century (Hummels (1999, 2007)). The second line of research which this research pertains to is the trade costs literature. This literature is mainly concerned with estimating the effects of reductions in trade costs on trade. Traditionally, the literature aimed to do this using gravity equations. We review the relevant literature in Chapter 3 of this thesis. We also present some background reading into the development of containerisation in Chapter 2. This is necessary as will become clear later because part of the analysis in this thesis is driven by the narrative.

A major contribution of this research is the collection of and use of data that has not been used in the economics literature before. This is presented in Chapter 4. We collect information on the countries' first adoption of containerisation from a specialist transport publication, Containerisation International Yearbook. Different countries adopt the container at different points in time. We view containerisation as a technological change manifested by countries' first handling of containers. Contrary to popular belief, containerisation was not exclusive to ports. In fact, containerisation is a comprehensive intermodal goods transportation system. The container can be shipped by sea on a containership, travel on a wagon inland by rail, and/or be pulled on a trailer by a truck. The data we collect encompasses two of the three modes of transport - ports and rail[2]. We have no information about containerisation on the road. This may introduce measurement error in our variable.

We exploit the time series and cross-sectional variation in the adoption of the technology in 157 countries in ports and rail as an identification strategy for estimating the effects of containerisation on bilateral trade. Based on the data we collect, we find that the introduction of container ports - outside the innovation country of the US - occurred exclusively between 1966 and 1983. From this data, we construct qualitative variables of containerisation for a panel of 157 countries and examine the impacts of containerisation on world trade during 1962-1990, which could be viewed as the period of global container adoption. We capture containerisation as a country specific qualitative variable that switches from 0 to 1 when a country starts containerisation either in ports or rail. Furthermore, we use a scientific product classification on the containerisability or suitability of shipping products in containers. This classification is based on the physical characteristics of the SITC 4-digit products in 1968. Products classified as suitable for containers in 1968 did not require any adjustments and could be readily transported in containers. Based on this classification, we also construct a 1-digit SITC product containerisability classification. We use the containerisability classifications is

[2]Air cargo transport was not widespread at the time of containerisation (Hummels (1999) and Harrigan (2010)). For the UK, between 1965 and 1979, 99% of total trade was transported by sea (Author's own computations based on data from National Ports Council). According to the UK department of transport, about 95% of international freight by weight was transported by sea in 2006, compared with only 0.5% by air (and the rest by the Channel Tunnel). According to the OECD (Korinek and Sourdin (2009)), ninety percent of merchandise trade by volume was transported by ship in 2007. The share of transport by ship could only have been higher in the period 1962-1990. Therefore, one can conclude that the only modes of transport that mattered at the time were sea and land transports. See also Hummels (2007).

our analysis in ensuing chapters.

We start our empirical exercise to identify the effects of containerisation on the aggregate bilateral trade flows in Chapter 5. In line with the literature that attempts to explain and predict trade flows, we start from a gravity model with the constructed container variables to estimate the effects of containerisation on the aggregate bilateral trade flows during the years 1962-1990. We estimate a traditional gravity equation in which we introduce the exporter- and importer-year varying container variables while controlling for country-pair and time FE. We find evidence for a strong economic and statistically significant effect for the adoption of containerisation by the origin and destination countries on bilateral aggregate trade flows in this specification. The structural gravity equation derived by Anderson and van Wincoop (2003) suggested that the estimates in this specification suffer from omitted variable bias since it fails to control for multilateral resistances or price terms which are in-turn functions of trade costs[3]. The inclusion of country-time effects allows us to capture multilateral resistance identified by the structural gravity literature and other time-varying factors that might be correlated with countries' decisions to invest in container ports. Since the country-time effects are collinear with the opening of container port facilities, we can only estimate the effects of containerisation when origin and destination country both containerise. Hence, containerisation in a bilateral trading relationship occurs when both the origin and destination countries have containerised. Also, to allow the regressions to run, we choose time points in the panel that are 5 years apart. This has the advantage of allowing some time for trade to adjust to containerisation. We estimate both a FE model and a first-differenced model. We argue that the first-differenced model has many benefits over the FE model. When estimating the models with the country-time effects, we find no effect for containerisation on the aggregate trade flows. However, we capture an effect for containerisation on manufacturing trade. This could be explained by the fact that not all products can be moved in containers. Also, containerisation is likely to have affected different products differently and hence aggregation may introduce bias (Anderson (2011)).

[3] Anderson and van Wincoop (2003) define multilateral resistances as the average barrier of two countries to trade with all their partners.

In Chapter 6, we suggest a product level or commodity estimation specification. Since we argue that not all trade can be moved in containers, we use the product containerisability classification described earlier to restrict our sample to products that were readily containerisable in 1968. We argue that these products did not require adjustments to be transported in containers and could be readily transported in containers whereas all other products may include products that became containerisable later on or that are sometimes strongly affected by containerisation because their intermediate inputs are containerisable. Causal statements are therefore clearer for containerised products. The panel nature of our data enables us to apply empirical models of treatments effects (Wooldridge (2010)) which have also been recently exploited in estimates of the effects of Free Trade Agreements (FTAs) on bilateral trade flows (Baier and Bergstrand (2007)). We decide to first-difference the data to allow the regressions to run given the size of the data set and we argue that a first-differenced model would be most suitable to identify and capture the effects of containerisation. The first differencing of the data also takes care of difficult to measure geographic factors, like government desires to act as container port hubs. The inclusion of exporter- and importer-time effects allows us to capture multilateral resistance identified by the structural gravity literature and other time-varying factors that might be correlated with countries' decisions to invest in container ports. Identification of the effects of containerisation therefore comes from the treatment of trade flows of the containerised pairs, controlling for any common changes in trade volumes that occurs for the exporting country with all its other importing countries, as well common changes to trade flows for the importing country with all remaining countries. We estimate that containerisation had large effects on containerisable trade. We also find that the effects of containerisation do not differ according to the level of product disaggregation. We consider full containerisation (ports and rail) and port containerisation only and find that estimates for the effects of full containerisation are higher than port containerisation. Another contribution of this research is that the nature of the estimated equations allows for a "horse race" between the technology variable and the policy or institutional variables. The effect of containerisation on trade in containerisable products at the 1- and 4-digit levels is estimated to be at least two-times of the effect of trade policy liberalisation, depending on the measure of trade policy being considered. When restricting the sample to explore heterogeneity in results, containerisation is estimated to have affected North-South trade the most, then South-South trade, and then North-North trade the least[4]. The narrative tells us that North countries were first to containerise and we argue that our container variable is likely to capture containerisation on the 3 modes of transportation (ports, rail and roads). Measurement error is therefore minimised in the case of North countries. Causal relationship is therefore clearer for North-North countries as we argue although the strong results are suggestive of a causal relationship in the case of North-South and South-South trade. We explore this further in chapter 7.

The nature of the empirical specification devised in chapter 6 allows us to examine whether the effects of containerisation decay or increase over time, or whether they precede the opening of the first container port in that bilateral pair. This is done in chapter 7 by including lagged and lead terms of the treatment variables. As per Wooldridge (2010), including a future level (lead) variable serves as a test for strict exogeneity. We find containerisation had contemporaneous as well as lagged effects on containerisable trade. This suggests that containerisation effects could be felt 10 to 15 years after the adoption of the technology. The estimated cumulative container effects are 6 to 10 times the estimated cumulative effects of the policy variables depending on the policy variable in question. Here too, we draw on the narrative to motivate our analysis. The narrative suggests that North countries were first to containerise. This means that any pre-container effects should not be there on our estimation for North-North trade. Also, as we discussed above, measurement errors are likely to be minimal in the case of North countries. This suggests that we should not have a lead effect for the container variable. We test for this in the sample of North-North countries. We find no evidence for a feedback effect (pre-container effect) in the sample of North countries - the early containerisers - which suggests that we can be confident about the causal relationship between containerisation and containerisable trade in this sample. This is not the case for the samples of North-South and South-South trade where we estimate a positive and significant coefficient of the lead container variable although the estimates are relatively small. The estimates for North-South and South-South trade are therefore suggestive of the direction of causation although we cannot be as confident about making

[4]North countries are all OECD countries up to 1990 minus Turkey. South countries are all other countries.

a causal statement as we are for North countries. Judging by the cumulative effects of the container coefficients, we find that North-South trade was affected the most followed by North-North and then South-South trade.

Just like policy variables, containerisation may be endogenous to world trade in that countries may choose to containerise because of their existing trade patterns. The issue of potential endogeneity of containerisation in explaining world trade flows is dealt with in different ways in this thesis. In chapter 5, we deal with endogeneity by including county-time and country-pair FE which solves for endogeneity coming from omitted variable bias. We also restrict the sample to sub-samples where endogeneity is less of a concern such as removing the top 5 trade partners of each country. In chapter 6, we take this one step further by dealing with another possible source of endogeneity which is measurement error. We argue that measurement error is likely to be minimal in the case of North-North countries since they are the countries that introduced and developed the technology first. In chapter 7, where we discuss the long term effects of containerisation, we make use of including lead terms along with the lag terms which serves as a test for strict exogeneity.

The thesis is thus divided into 6 core chapters (other than the introduction and conclusion). Chapter 2 explores the background of the container since the economic analysis in the rest of the thesis is driven by the narrative as will become clear. Chapter 3 sets the motivation, the research question, and the relevant literature. In Chapter 4, we describe the data on containerisation. We then construct our measure for containerisation to be used in the remainder of the thesis. Chapter 5 looks to identify the effects of containerisation on the bilateral aggregate trade flows. Chapter 6 introduces a product dimension to the identification specification. Finally, Chapter 7 investigates whether the effects of containerisation persist, increase, or decay over time.

Chapter 2

A Historical Narrative of the Container

2.1 Introduction: Containerisation and World Trade

Before the container, loading and offloading ships was still as labour intensive as it used to be in the times of the Phoenicians. Transporting goods was expensive that it did not make economic sense to ship many things halfway across the United States much less halfway around the world. In the 1960's, the first container ship made its way across the Atlantic from New York to Europe. With that, the container revolution was set to start.

According to Donovan and Bonney (2006) in their illustrative book, containerisation "changed the industry's economics as drastically as the switch from sail to steam had done a century ago". Hence, containerisation is the biggest change to hit shipping since the switch from sail to steam propulsion a century earlier. Before the container, world trade was concentrated in basic commodities such as fuel, grain, and metal ores. But now anything from socks to machine parts is being traded and transported by ship. The container made it possible to manufacture the good where it is cheapest to do so and to transport it to world markets. It is no secret that Wal-Mart, the largest US importer of containerised good, is able to operate an efficient supply chain, the in-time delivery system, thanks to containerisation. Many retailers copied the Wal-Mart system successfully. The role of containerisation in our global economy was put to a test in 2002, when a strike by the International Longshore and Warehouse Union (ILWU) closed US

Coast ports for 10 days. The shutdown of ports was almost immediately visible, resulting in empty store shelves and idle assembly lines [1].

Containerisation did not only change shipping as we know it but also helped redraw the global maritime map. Traditional maritime centres such as New York, Liverpool, and London saw their docks decline into obsolescence. The congested docks of these metropolitans were not suited to handle containers and the berths were not deep enough. New ports were needed. Massive ports were built in Rotterdam, Busan, Singapore, and Shanghai among others. In the UK, Felixstowe, unheard of before the container wave, became the UK's busiest container port.

The container also changed the local economic picture. For centuries, manufacturers clustered near the docks for easier delivery of raw materials and faster shipment of finished goods. This was evident around the London Docks and the Port of New York which were host to major manufacturing bases. With containerisation came the ease of transfer of the container between the ship and land modes of transport. Manufacturers no longer found it necessary to locate near a port or close to their customers. They could locate to distant locations where they could operate more cheaply. The London docks as well as the Port of New York lost their manufacturing bases as a result to inland and overseas locations[2].

Also entire communities changed beyond recognition. It was clear from the beginning that containerisation would eliminate the profession of dockworkers, but no one could imagine that it would cause massive job losses among workers whose livelihoods were tied to the presence of the nearby docks. The once thriving dockers' community of East London with its unique culture no longer exists. On the site of what used to be the West India Docks now stands London's new financial district, Canary Wharf. The surrounding boroughs are now inhabited by young professionals employed by the big banks and financial institutions in Canary Wharf.

No one anticipated that the container would result in vast changes in where and how goods are manufactured or that it would help integrate East Asia with the rest of the world. Before the container, big industrial complexes would manufacture products from start to finish. Nowadays, smaller specialised plants ship components and half-finished

[1] Donovan and Bonney (2006)
[2] Levinson (2006) page 2

goods to one another in ever lengthening supply chains. Containerisation went hand-in-hand with a new world economic order. Poor and emerging countries became suppliers to wealthy countries and could climb out of poverty. Factories in Malaysia could deliver blouses to Macy's in New York more cheaply than could manufacturers nearby. The United States imported four times as many varieties of goods in 2002 as in 1972. It is no secret the container allowed for raw materials to be shipped to distant countries to make use of their cheap labour to turn them into finished goods that are then sent by containers to markets[3].

It is rather fascinating that it remains cheaper nowadays to produce toys in China and ship them thousands of miles than manufacture them locally. Feenstra (1998) estimates that a Barbie doll costs only $2 to produce. The raw materials for the doll are obtained from Taiwan and Japan. Assembly takes place in Indonesia, Malaysia, and China. Of the $2 export value for the dolls when they leave Hong Kong for the United States, about 35 cents covers Chinese labour, 65 cents covers the cost of materials, and the remainder covers transportation and overhead. The dolls sell for about $10 in the United States.

The modern (container) port is a factory. Major ports have dozens of berths that accommodate mammoth containerships up to 1,100 feet long and 140 feet across, carrying nothing but metal boxes, thousands of them. On the wharf, enormous cranes go into work as soon a ship docks. The cranes themselves are engineering masterpieces. They rise 200 feet into the air and weigh more than 2 million pounds. Their legs are 50 feet apart to allow several truck lanes and even train tracks to pass beneath. Within 24 hours, the ship is discharged of its thousands of containers, takes on thousands more and moves on its way[4].

The result of the new system is that a container can leave a factory in Malaysia, be loaded aboard a ship, and journey the 9000 miles to Los Angeles in 16 days. A day later, the same container is on a unit train to Chicago, where it is transferred onto a truck headed for Cincinnati. The 11,000-mile trip from door to door can take as little as 22 days, at a cost lower than a single first-class air ticket. Significantly, no one has touched the contents or even opened the container along the way[5].

[3]Levinson (2006) page 3
[4]Donovan and Bonney (2006)
[5]Levinson (2006) page 7

We start our investigation into the effects of containerisation in this chapter with a historical account of the container. The narrative is very important to our analysis as will become clear in the ensuing chapters. The outline for this chapter is as follows. In section 2.2, we present the problems that existed in ports from damage to the goods, pilferage and labour issues which were the main motives behind the development of containerisation. In section 2.3, we present a historical account of the container to better understand the conditions in which the container technology was developed and the sort of problems that it came to deal with. We believe that it is important to present a brief historical account of containerisation since our analysis will be driven by the narrative as will become clear and to understand our container variables better in ensuing chapters. In section 2.4, we discuss the effects of containerisation on economic geography and how it impacted the previous maritime centres of New York, London, and Liverpool. We outline how containerisation meant that the geography of ports was a determinant of whether a port could become a container port or go out of business. In section 2.5, we present some evidence on the effects of the container mainly from the business literature. Comprehensive quantitative evidence in the economics literature remains lacking, we argue.

2.2 The Scene in Ports Before Containerisation: Damage, Pilferage, and Labour Issues

Except for the use of steam-powered winches and cranes, shipping was still a primitive industry in the 1950s before containerisation set in. Longshore gangs were handling breakbulk cargo the same way the Phoenicians did thousands of years ago[6]. The process still relied heavily on muscle and manpower. Ships remained in ports for days while longshoremen wrestled individual boxes, barrels and bales into and out of tight spaces below decks.

At the factory gates, goods would be loaded piece-by-piece, crate by crate on trucks or railcars. The trucks or rail would deliver the thousands of pieces to the port. Each piece had to unloaded separately, accounted for on a piece of paper, and stored in transit

[6] *Bulk* and *Breakbulk* are terms used in shipping. *Bulk* cargo refers to commodities such as grain, coal, metal ores, and others that are loaded in the holds of ships without packaging or sorting. *Breakbulk* cargo, also known as general cargo refers to individual items that are packaged and handled separately. A more formal definition of bulk and breakbulk cargo is presented in chapter 4

sheds along the docks. When a ship had been loaded, each item had to be brought out of the sheds and warehouses, counted once more, and moved to shipside. The scene at the docks was that of a beehive. Crates, casks, bags, cartons, and drums lined the dockside. There might be loose pieces of lumber, baskets of fresh produce, and even exotic animals among the cargo awaiting loading. In one footage of the port of London Docks from back in the days, one could even see elephants being used to carry heavy cargo[7].

The loading part was the role of longshoremen, also known as dockers. On the pier side, a gang of dockers would assemble part of the cargo on top of a wooden pallet. The pallet would carry stacks of loose cartons and bags and the longshore workers would warp cables around the cargo and tie the ends together. There would be a winch installed on the deck of the ship operated by a deck man. The deck man would lower a hook with his winch and the dockers would connect the cables to the hook. The deck man would then hoist the cargo and manoeuvre it over an open hatch and lower it into the ship's hold. The hook is released immediately and deployed quickly to grab the next load. Another gang of men would be waiting in the dim and usually moist hold of the ship to secure the cargo in place. Piece by piece, bags and crates are tucked and pushed in the empty spaces that fit them in the ship's hold. Moving the goods off the sling board was done using carts, forklifts, and in many cases brute force. Every docker was equipped with a steel hook with a wooden handle that would be used to handle heavy bags to jerk them into place.

Unloading was just as labourious. It is almost impossible to avoid damaging the goods in the circumstances. Damage was frequent and expensive. There was another problem looming on the docks that daunted shippers and port authorities alike. The antagonistic labour-management relationships meant that theft was the rule rather than the exception. Labour found that the deteriorating work conditions should be met with theft and pilferage as a means of retaliation. The problem worsened when trade in high-valued products started to gain momentum after World War II. Dockers would tap whiskey from sealed casks and steal electronic devices for home use[8].

Ports in the 1950's were highly inefficient places. The problem was more evident

[7]London's Lost Docks, DVD, Timereel Studios
[8]Levinson (2006) page 28

in ports where labour unions were very active. Dockers' unions resisted anything that would endanger the security of the existing jobs. Mechanisation was met with fierce resistance. Ports were plagued with strikes. Any attempts to increase productivity were met with protest. Even absurd practices such as the welt - a practice under which half of each gang would leave work often to the nearest pub and then an hour or two later the other half would alternate with the first half - was very difficult to eliminate. Labour productivity was low as a result[9]. The result of these problem was obviously very high labour costs. Possibly the greatest threat to containerisation came from labour unions who saw in it a great menace to their job security.

The solution to the above problems was obvious as will become clear in the next section: instead of loading, unloading, shifting, and reloading thousands of loose items, why not put cargo into big boxes and just move the boxes?

2.3 A Historical Account of the Container

None of the previous attempts to introduce sealed boxes in which goods can be transported gained commercial ground. It took a trucking magnate to launch the idea of the container in its current form. Malcolm McLean from North Carolina was keen on expanding his trucking business. His company faced congestion on the American highways as well as in ports where trucks delivered and picked up shipments.

McLean had figured out that by moving loaded trailers onboard ships, he would avoid repeated cargo handling and the related high labour costs that were characteristic of traditional shipping. Also turnaround time would be greatly reduced, and so would be losses from breakage and pilferage.

When McLean decided to move trailers on ships, he started to look for appropriate space to run his proposed operations. The Port of New York Authority which runs the ports of New York and New Jersey was looking to revive its slumping business. The port of Newark, New Jersey, was perfectly positioned across the harbour from New York City and offered ample space for McLean's trucks. The port authority was very receptive of McLean's concept of moving trailers by sea and the two sides struck a deal.

To realise his plans to move trailers by sea, McLean succeeded in acquiring Waterman

[9]Levinson (2006) page 28

Steamship Corporation and its daughter company Pan-Atlantic Steamship Corporation. Waterman was one of the world's largest shipping companies at the end of World War II. The acquisition provided him the rights to operate between the Gulf and East Coast.

As soon as McLean took control over the shipping giants, he sent two of their surplus World War II tankers to the shipyard for conversion into trailerships. In September 1955, McLean received his much sought-after legal endorsement to operate his trailerships. The Interstate Commerce Commission (ICC) which oversaw domestic shipping as well as trucking and railways granted Pan-Atlantic preliminary approval to use ships to move truck trailers. With the new authorisation, experimentation with containers would start in the USA in 1956.

2.3.1 The First Containerships

McLean was concerned that trailers' wheels and undercarriages would occupy space that otherwise might be used to carry cargo. Even better, trailer bodies could be stacked, whereas trailers with wheels could not. He found a company that was ready to build reinforced aluminium containers. The containers were being stacked two-high and were locked onto trailer chassis upon reaching their destination.

On April 26, 1956, the first container was loaded onto the *Ideal X* at Port Newark, New Jersey. The *Ideal X* was a converted World War II tanker that was redesigned to carry trailers on its deck while still being able to carry oil at the same time. The trailers being hauled on the top deck had been separated from their wheels and chassis[10]. The container as a mere box was being used for the first time. The boxes were reinforced metal structures designed to withstand harsh weather and rough seas. The Ideal X left Newark with 58 containers bound for Houston and made history for being the first containership to ever sail.

Experts estimated that the cost of loading the *Ideal X* stood at 15.8 cents per ton. Comparatively, loading cargo breakbulk style on a medium-sized ship cost $5.83 per ton in 1956[11].

With the idea of stacking containers on top of each other, McLean realised that economies of scale could be exploited. A new crane system was developed to enable the

[10]The container as a term was still not widely used at the time.
[11]Levinson (2006) page 52

automisation of the loading and offloading of containers.

By the end of 1956, 67,000 tons of containerised freight had been moved through Newark. Soon the converted tankers that were employed in the beginning were replaced by former military freighters that offered more room for containers. Each of the newly converted ships was redesigned to carry 226 containers stacked in cells below and on deck. The ships were equipped with onboard cranes to handle the lifting of containers in the tight confines below deck. Again this was a new innovation in shipping[12].

In August 1958, Pan-Atlantic started a new service to San Juan, Puerto Rico[13]. Prior to the successful sailing of *Fairland*, McLean had a standoff with the San Juan longshoremen who refused to unload his ship, the *Bienville*. When the first containership arrived in San Juan, the longshoremen refused to unload it. Four months of negotiations ensued while two ships sat idle at port. The union requested that Pan-Atlantic use two large 24-man gangs to handle containerships. McLean finally bent to the union's demands. Service to Puerto Rico was thereby resumed and crisis averted. This however marked the beginning of the resistance movement to containerisation and the long process of weakening the longshoremen unions.

On the West Coast, Matson Navigation Company started container service between San Francisco and Hawaii. Matson explored the disadvantages of operating from an already congested big port such as the old piers of San Francisco. Matson opted to operate its container services from the much smaller but more spacious Alameda, on the east side of San Francisco Bay. On January 9, 1959, the world's first purpose-built container crane went into operation in that port. The crane could load one 40,000-pound (18 tons) container every three minutes. At this rate, the Alameda terminal would be handling 400 tons an hour or 40 times the productivity of one longshore gang using ship winches[14].

2.3.2 Expansion of Containerisation in the USA

The West Coast-Hawaii service proved very successful. Matson reported that "70 percent of Hawaii cargo that was amenable to containerisation was moving in containers" by

[12]Levinson (2006) page 56 and page 132.

[13]Puerto Rico is not effectively an independent nation but rather an "unincorporated territory" of the United States

[14]Levinson (2006) page 65

1963. Shipping costs in the market had been reduced by 25%.[15]. Hawaii benefited from containerisation with more varieties being available on the market. Fresh produce, meat, eggs, and dairy could be transported in refrigerated containers from the mainland. The pineapple production Hawaii is also said to have benefited greatly from the new developments. Fresh Hawaiian pineapple was now readily available in US supermarkets in big volumes and at affordable prices.

In 1960, McLean's Pan-Atlantic Steamship Corporation changed its name to Sea-Land Service Inc. At that time, the Port of New York authority was building a new terminal in the New Jersey marshes that became known as Port Elizabeth. McLean was quick to move his company's operations to the new terminal. The new terminal provided ample space for handling and storing containers. The new investment proved to be a smart one. As containerisation advanced, New York's old piers started to lose traffic to the deeper and more spacious New Jersey terminals. The same happened on the West Coast where San Francisco was losing to the nearby Oakland.

In the early 1960's, McLean was still trying to establish himself in the domestic market. However, at that time, the US military was in dire need for extra capacity for military shipments to its numerous bases and operations around the world. McLean's new innovation represented in containerisation would become very popular in the military cargo market.

Puerto Rico was an attractive market for American carriers. The economy of the island nation was growing at 8 to 10% per year due to US government's development programme, Operation Bootstrap. The programme enticed US manufacturers to take advantage of the cheap labour and set up manufacturing facilities on the island. They brought their raw materials to the island and shipped their finished products out to the mainland. The demand for shipping was exploding as a result. The Puerto Rico experiment provided the world with the first model of offshoring and fragmentation of production and the container was key in this experiment.

Also, economic development in the island meant that many workers on the island enjoyed steady income for the first time. Demand for merchandise from the mainland increased, filling the ships making their way to Puerto Rico. Total trade between Puerto

[15]Donovan and Bonney (2006) p.81

Rico and mainland USA trebled during the 1960s and it all went by ship[16] . The island would soon serve as a hub for feeder services to the US Virgin Islands. This was the precursor of what became known as the hub and spoke system.

2.3.3 Containerisation on the Atlantic

After experimenting on US domestic routes which gained ground, US carriers were racing to launch international container services. Two American carriers were the first to succeed in launching the much-anticipated trans-Atlantic container service. These were United States Lines and naturally Sea-Land of McLean. The North Atlantic route was the busiest shipping route on the planet at the time.

On March 1966, the *American Racer* departed from New York for Europe (London) with only containers onboard. Sea-Land was not far behind. Its cellular containership *Fairland* departed from Port Elizabeth, New Jersey on April 23, 1966 to Rotterdam, Bremen, and Grangemouth, Scotland. The ship was carrying 226 35-foot-long containers. The ship was also equipped with deck cranes. Containerised freight for England would be transported to Felixstowe by a feeder service from Rotterdam. London's port was notorious for its strained labour relations and its congested docks that did not leave much room for container handling.

Following the successful launch of transatlantic containerisation in 1966, many more shipping lines became keen to join in. By June 1967, 60 companies were offering container services to Europe.

In June 1967, another important milestone in the history of containerisation was reached. The International Standards Organization (ISO) agreed to standardise the dimensions of the container. This was an important development because land and sea carriers are now able to handle one another's containers. Also corner lifting devices were standardised. The following container sizes were adopted: 8 ft. wide x 8 ft. height x 10 ft., 20 ft., 30 ft., or 40 ft. long. Standardisation of the container (ISO agreement) provided a stimulus to the container.

[16] Levinson (2006) page 73

2.3.4 Containerisation in the Pacific

It took a major war, the Vietnam War, to prove the merit of containerisation according to many commentators. The US military embraced containerisation at an early stage. The Defence Department was sending large shipments of pilferage-prone military goods and equipment by container for its bases in Europe. Since many of these bases were located in Germany, Bremen and Bremerhaven flourished as container ports. The military shipment market was also prosperous on the Pacific market where the US was increasing its presence in Southeast Asia.

McLean signed contracts to carry Army freight from the West Coast to Okinawa, the Philippines, and Vietnam. The Vietnam contract was a 2-year contract worth $70 million. The Defence Department estimated that it had saved more than $200 million on transportation costs to Vietnam from containerisation by mid 1968, a witness to the cost savings brought about by containerisation[17].

At the time, Japan, Korea, Taiwan, the Philippines, and Hong Kong were manufacturing consumer electronic products, watches, and clothing and exporting these to the US. Such products were vulnerable to damage on the high sea and pilferage and therefore ideal for containerised shipping.

Kobe was the fastest port in Japan to adopt containerisation. Three container terminals had been built there. The early investment proved very wise as containerisation caught on and Kobe became the biggest Japanese port. Yokohama was a different story. Failure to invest early on in the process led the port to lose the race to Kobe.

2.3.5 Containerisation and Intermodal Transport Infrastructures

Subsequent integration of rail and ocean liner container services encouraged the growth of intermodal coordination. As transportation companies began to reach beyond the modal boundaries that had limited their earlier operations, the benefits of containerisation became increasingly obvious (Donovan (2004)).

The British Rail freightliner service began operations in 1966. The system gained great success quickly and was able to handle an estimated 600,000 containers in 1971. In the beginning, London was connected with Glasgow, Liverpool, Manchester, and Aberdeen but the network grew considerably and quickly thereafter. The majority of

[17]Levinson (2006) page 180.

freightliner business originated in the UK but a considerable 40% came from international trade[18].

British Rail was quick to realise the potential of the container and extended its inland system with the introduction in 1968 of British Rail containerships operating from Harwich to Zeebrugge and Rotterdam.

In response to containerisation, and in an effort to avoid being left out, the railways of Europe came together in 1967 and formed Intercontainer, The International Association for Transcontainer Traffic. This company was formed to handle containers on the Continent and compete with traditional shipping lines. At the time, British Rail was already operating a cellular ship service between Harwich, Zeebrugge, and Rotterdam and a freightliner service between London and Paris. Initially 11 European lines signed to Intercontainer, and soon after 8 other country lines joined the league. The countries represented in the new system were: Austria, Belgium, Denmark, France, West Germany, East Germany, Great Britain, Greece, Hungary, Ireland, Italy, Yugoslavia, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland[19].

Intercontainer started operation in May 1968 and it handled almost all international container traffic traveling by rail in Europe. The new company was represented in each country by the railway administration concerned. The company made matters simple for the shippers looking to have their goods transported over the borders. Door-to-door tariffs were being quoted and one consignment note per box was issued. Invoicing was centralised in Basel and the Swiss Franc was being used and Intercontainer became the 'European Railway' as a result.

Containerisation International estimated that the cost of Cost of moving 1 twenty-foot equivalent units (TEU) between Paris and Cologne was FFr 1,025. This was estimated to be around 75% of the equivalent road costs. The traffic handled by the company amounted to around 18,500 TEU containers per month in the early 70s[20].

[18]Containerisation International Yearbook 1973, page 58
[19]Containerisation International Yearbook 1971 page 43
[20]Containerisation International Yearbook 1972 page 41

2.3.6 Further Developments in Containerisation: The Oil Crisis and the Computer

Containerisation turned shipping lines into companies that offered a transportation service. They no longer cared only for the port-to-port transport but had to take responsibility for inland transportation of containers by rail and truck. It was no secret that containerised shipping required heavy capital investments. The largest cost to the carriers is the ship and ships were growing bigger. In the early 1970's, a fully containerised 50,000 gross ton vessel cost about 8 million pounds plus another 3 million for the containers [21].

To make matters worse, the Yom Kippur War broke out in 1973 between Syria and Egypt on one side and Israel on the other side. Israel was backed by some European countries and the United States, and the Arab oil countries retaliated by imposing an oil embargo on the US, Western Europe and Japan. The action led to what became known as the oil crisis and oil prices shot up dramatically.

The price of oil increased four-fold on what it had been before the war. Most shipping lines felt the pain of the high oil prices in their margins. Many ships that were designed to steam at higher speed for quicker delivery were deemed uneconomical. Hummels (2007) suspects that high oil prices could have reversed some of the cost savings introduced by the container.

It is true that prior to containerisation, shipping companies viewed themselves as port-to-port service providers. That was about to change however. Containerisation introduced what later became known as intermodal transportation. Containerisation was designed to make door-to-door service, between the exporter and the importer, possible. This meant that container lines had to coordinate the inland leg of the trip as well. This also meant that many shipping lines had to partner up with railway companies and truckers to arrange for inland transportation. As a result, many shipping lines did not have a grasp on what happened to their containers beyond the port gates.

American President Lines (APL) realised the problem early on when bad weather in the winter of 1977 closed rail lines across much of the United States, and railways were unable to track the containers. APL, being a subsidiary of an oil and gas exploration company, started applying automation to its shipping operations and installed a tracking

[21] Whittaker page 18

system for its containers on the sea. The carrier quickly came to realise that expanding its tracking system inland would be necessary. This was the first attempt to combine the power of computers with containers.

The increase in efficient rail-water services made it easier for Asian goods to be delivered to US markets. Stacktrains are said to have "hastened the shift in the world's trade axis toward Asia". Goods would be delivered in container ships to the West Coast where they are transported by rail to their destination within the US. The growth of these shipments turned the ports of Los Angeles and Long Beach into the fastest-growing US container ports. In 1987 Long Beach became the busiest US container port surpassing the port of New York-New Jersey.

With the emergence of new trade and transportation patterns, APL no longer found it necessary to restrict its ships' designs to fit through the Panama Canal. After all, it saves money and time to ship the goods from Asia to the West Coast and then deliver inland by rail. The Panama Canal locks were 110 feet wide, 1,000 feet long and 39.5 feet deep. APL announced what it called "post-Panamax" ships in 1986 and the ships entered service in 1988. The ships had a capacity of 4,300 TEU .

The door was now wide open for even bigger ships. In the 1990's, orders were placed for ships with capacities of 5,000 and 6,000 TEU. This would not be the end of it however. In 2005, ships in excess of 10,000 TEU were built and put in service. By comparison, McLean's *Ideal X*, hailed by many as the first container ship, carried only 58 33-foot containers, or the equivalent of 95.7 TEU.

2.4 Changing Fortunes: Containerisation and Ports Economic Geography

The changing economies of shipping meant that the late containerisers faced potentially serious consequences. McKinsey's recommendations to the British government (McKinsey and Company (1967)) advised that the new economies of scale introduced by containerisation meant that Britain required only a couple of large container ports for all its imports and exports. Also shipowners wanted to keep their expensive container ships on the sea transporting goods for as long as possible to recover the high costs. This meant that containerships made one or two stops only on their journeys. Ports that invested early on in container ports were more likely to attract shipping lines to call at them. Secondary ports would not see transatlantic ships but would get only feeder services. Other ports were disadvantaged by their geographical location such as London. Given the new industry dynamics, some ports disappeared, some rose to prominence, and some were built from scratch. Some of the world's great port cities saw their ports decline and disappear, while insignificant towns found themselves among the great maritime centres.

Nowhere was the transformation more apparent and turbulent that in New York in the USA and London and Liverpool in Britain. We discuss below how containerisation affected what used to be the world's maritime centres.

2.4.1 The Port of New York and containerisation

New York was a world maritime and shipping centre. That was before containerisation came. The onset of containerisation proved to be disastrous for New York City. The changes in the shipping industry were beyond the city's capacities to handle. Despite spending enormous sums of money to update and keep its piers operational, New York's piers were bound to become obsolete. This was a perfect example of how a new technology would change the fortunes of a geographic location to the advantage of another location.

In the early 1950s, the Port of New York handled one-third of America's seaborne trade in manufactured goods. The good fortune of NY was even bigger with high-valued goods. New York as a port had significant disadvantages though. The piers - NY had 283 of them at mid-century - were located along the Manhattan and Brooklyn waterfronts. The location was far from ideal for commuting freight to and from NY from the rest of the country. The railroad tracks were across the harbour and the Hudson River in New Jersey. This meant that freight railcars had to be moved from New Jersey to the NY piers in barges and lighters pushed by tugboats. The situation was only made economically viable by a ruling of the ICC that required rates for Brooklyn and Manhattan that are similar to the rates for New Jersey bound freight. The railroad companies had to throw in the lighter trip for free.

A metropolitan city such as NY housing one of the busiest ports in the world at its heart clearly had another big disadvantage. This disadvantage became more apparent as the trucking industry overtook railway as the first choice of domestic freight transportation. Trucks had to navigate through the congested streets of Manhattan to reach the piers. It became normal for trucks to queue for an hour or two to enter a pier for a delivery or a pickup.

The port was an important employer and a source of job creation in the city. In 1951, it was estimated that 100,000 New Yorkers worked in water transportation, trucking, and warehouses. Then there were the manufacturers that located near the port for ease of shipping. The Hudson River and the Brooklyn waterfront housed many food-processing plants and dozens of factories in the chemical and pharmaceutical industries. The manufacturing jobs that associated with the factories ran in the thousands. In short, the stakes were very high.

But none of the above disadvantages threatened the position of the Port of New York as the labour issues did. The docks were frequently prone to labour strikes. The high risk of labour disruptions encouraged shippers to use other ports. Crime and theft also contributed to the demise and drove shippers away.

Most of the New York piers were decaying. Many dated back to the end of the nineteenth century and some were very narrow that a large truck could not turn around. Other ports were literally collapsing in the water. The costs of building new piers were prohibitive.

The Port of New York Authority is a bistate agency of New York and New Jersey. The plans to modernise and rebuild the New York piers were faced by fierce resistance from New York officials and the International Longshoremen's Association (ILA), the labour union of the port. New York officials considered the piers to be a gold mine. They thought that if they modernised the city piers themselves, the piers would earn the city big money.

The city of Newark, New Jersey, did not have similar objections. Its docks were obsolete and desperate for an overhaul. The city agreed to lease its docks to the Port Authority in 1947. Between 1948 and 1952, $11 million were spent to rebuild wharves and deepen the channels. Waterman Steamship Company agreed to move from Brooklyn to a newly built terminal at Newark. Late in 1953, McLean made his desire to build a terminal on New York Harbour known to the Port Authority. His plans to drive trucks onto ships was never heard of before. The Port Authority was however very eager to attract new business to its new investment. Besides, the new facilities at Newark could cater to McLean's ambitions with their open spaces and easy access to the railway tracks and highways. All of these were advantages that New York was not in a position to provide.

Soon another project was announced. A new port would be built just south of Port Newark. Port Elizabeth would become the largest port project ever undertaken in the United States. The Port Authority was preparing for the age of containerisation. Newark was already attracting business away from New York and the announcement of the new port sounded alarm in New York.

In 1955, before McLean had started his container service out of Port Newark, New York started pumping cash into its old piers in an attempt to keep its shipping business. The stakes were very high after all and New York could not afford losing more business to New Jersey. The spending programme was estimated at $130 million, the equivalent of $800 million in 2004 dollars.

The problem was that the new plans did not address the disadvantages inherent to the city of New York. Costs were simply too high for shippers and shipping lines in comparison with other ports. Geographic disadvantage was still an issue and trucks would still have to deal with severe congestions in Manhattan and Brooklyn. Labour problems were not addressed either. In fact, the opening of one of the first rebuilt piers was delayed by a dispute between the port and the ILA. None of the city's plans envisaged any role for containerisation, a mistake that would prove fatal for the port.

With the start of its container service, Pan-Atlantic was attracting increasing trade to its terminal in Newark and it was expanding its operations in the port very fast. A government study at the time estimated that container shipping cost 39 percent to 74 percent per ton less than conventional shipping [22].

Cargo tonnage handled at Newark continued to surge while tonnage on New York's side dwindled. In just four years, New Jersey's share of total port traffic doubled from 9% to 18%. Port New York was still expanding without an eye for containerisation. It was clear that the investments were going to waste as the New York piers slowly started to shut down. Port Elizabeth on the other hand was designed as a container port from the start. When Port Elizabeth finally opened for business, Pan-Atlantic, now named

[22] Levinson (2006) page 91

Sea-Land opened its own terminal at the new port in 1962.

As shipping lines started looking to take containerisation internationally, the Port of New York Authority was still expanding. In 1965, several carriers announced plans for containerised ships to Europe. It was clear that their choice would fall on Port Elizabeth to launch their services. Only Port Elizabeth had the space for the container handling facilities.

In 1960, containerised freight accounted for 8% of the port's general cargo tonnage. In 1966, one third of the port's total tonnage came to New Jersey and 13% was containerised tonnage[23]. In 1970, New Jersey's share of the port's general cargo reached 63 percent. Two years later, more than half a million containers made it to the New Jersey docks[24].

With regards to labour, in 1963-1964, Manhattan docks used 1.4 million labour days. The figure slipped below a million in 1967/1968, 350,000 in 1970/1971, and dropped to 127,000 in 1975/1976 - a 91% decline in employment in 12 years[25]. On the New Jersey side, there was a period of shortage of labour. Forty ship lines were operating from Port Newark and Port Elizabeth in 1973.

By the mid 1970s, the New York piers were mostly shut. In 1974, the New York docks handled only one fiftieth as much as in 1960[26]. The effects of the collapse of the shipping industry in New York rippled through the local economy. Manufacturing was hit hard. In 1964, New York housed over 30,000 manufacturers employing close to a million workers. Two-third of the manufacturers were located in Manhattan. Between 1967 and 1976, New York lost a fourth of its factories and one-third of its manufacturing jobs[27].

2.4.2 The Scene in Great Britain: London and Liverpool

In the early 1960's, London and Liverpool were by far Britain's biggest ports. By the early 1970's, London Docks completely shut down and Liverpool had become almost entirely irrelevant to shipping lines.

On the labour scene, the labour union under which dockers and stevedores fell was

[23] Levinson (2006) page 94
[24] Levinson (2006) page 96
[25] Levinson (2006) page 96
[26] Levinson (2006) page 97
[27] Levinson (2006) page 99

the Transport and General Workers Union (TGWU). In March 1966, United States Lines carried the first large containers along with other freight en route from New York to London. London was not equipped with container loading and unloading facilities at the time. Containers had to be transferred from ships onto lighters to bring them to port from deep waters.

In April 1966, Sea-Land's Fairland carrying only containers made a trip across the Atlantic to Rotterdam, Bremen, and Grangemouth. With barely a year's notice, Rotterdam and Bremen had lengthened docks, deepened channels and begun installing container cranes. London did not and so Fairland did not even bother calling there.

London's once formidable docks were clearly not well suited for container shipping. London's geographic location was a clear disadvantage. The docks were grouped in sheltered enclosures off the Thames. Large vessels had to unload into lighters nearer the mouth of the river. Moreover, the prospect of having hundreds of lorries congesting the narrow streets of East London was daunting.

Liverpool's ageing docks were no more attractive than London's. The dismay in London and Liverpool had alarmed the British Transport Docks Board (BTDB). The Board turned to McKinsey and Co for advice.

McKinsey came back with a much-discussed report titled "Containerisation: Key to Low Cost Transport" in 1967. The McKinsey Report predicted freight savings of 50% through containerisation. The report also forecasted an eventual 70% reduction in cargo ships (vs. containerships) and a 90% reduction in the number of dockers and stevedores handling general cargo. McKinsey forecasted that container shipping would consolidate around a few companies using gigantic ships carrying standardised containers. Ports have to be very big therefore to cope with the sizes of the ships and the increased trade effect. The report also anticipated that containerisation would cut Britain's ocean freight bills in half but only if intermodal transport is used to link a few container ports to the rest of the country by rail and road.

In reaction to the report, the BTDB began a major port upgrade programme that would lead to spending £200 million between 1965 and 1969. The Port of London Authority had also ordered the building of a £30-million container complex at Tilbury, 20 miles down the Thames from London. Government had hoped that Tilbury would become Europe's Container Port. Another container port was built at Southampton.

As for Liverpool, Mersey Docks and Harbour Board began a container terminal at Sea Forth north of the city.

Tilbury opened in 1967 but not for too long. The labour union was not happy with the government's policy of encouraging permanent employment at the docks rather than daily hiring which was the norm before the container. A ban on containers at Tilbury was imposed by the Union from January 1968 in the hope that this would deter the government.

At the same time Tilbury was being furnished by the latest in container transport systems, a new port was being rebuilt at Felixstowe, 90 miles northeast of London on the North Sea. Felixstowe was a privately owned port controlled by an importer of grain and palm oil. The owners of Felixstowe could foresee the opportunity presenting itself due to containerisation. They spent £3.5 million to reinforce a wharf and install a container crane.

In July 1967, a small ship of Sea-Land shuttling containers back and forth to Rotterdam started a service to Felixstowe. Soon after, Sea-Land added ships calling directly from the US. The good fortunes of Felixstowe did not materialise until Tilbury closed due to strike in 1968. Overnight, Felixstowe had become Britain's biggest container port and this is still the case until today.

In 1969, Felixstowe was already timetabled for 2-3 trips across the North Atlantic and several feeder services to Rotterdam. In total, 1.9 million tons of general cargo was processed in Felixstowe in 1969, every bit of it in containers. The productivity gain due to containerisation was estimated at 66% higher average tonnage per man-hour in just 4 years[28].

The London Docks started closing one after the other in the wake of containerisation. As Tilbury opened, the East India Docks closed in 1967. The St. Katherine Docks were shut in 1968. The nearby London Docks followed immediately, and the Surrey Docks closed in 1970. Of the 144 wharves that had operated in London before 1967, 70 closed by the end of 1971 and all of the rest followed soon after. The number of dockers fell from 24,000 to 16,000 in 5 years. Factories and warehouses which located near the docks for easier access to material and export markets began to move away and as a consequence, the waterfront communities tied to the port began to disintegrate.

[28]Levinson (2006) page 205.

By the time Tilbury was finally allowed to open its docks to container ships, London had lost its position as the maritime centre of Europe to Rotterdam. Rotterdam is the perfect example of how technological change provides opportunities if taken advantage of. The Dutch were very quick to equip the port with container facilities as soon as the opportunity presented itself. Rotterdam spent $60 million to build the European Container Terminus which paved the way for Rotterdam to become the largest container centre in the world.

Tilbury had lost its potential of becoming Britain's biggest port to Felixstowe, which was by the time Tilbury reopened for business already the calling port for most major shipping lines. Felixstowe would continue to grow exponentially in the future. In 1968, 18,252 containers made their way through Felixstowe. In 1974, this figure would grow to 137,850 containers.

The story in Liverpool was quite different. With the opening of new container ports across Britain, Mersey Docks and Harbour Board experienced immense financial troubles that the parliament had to approve a financial bailout in 1971 and the government took over the city's docks. In 1972, after major constructions, the Royal Sea Forth Docks opened with a new pier complex including 3 terminals for containers. But Liverpool had lost its competitive advantage in the process of containerisation. In 1973, Britain joins the EEC (European Economic Community) and its trade becomes more associated with the continent rather than the US and its (former) colonies.

2.5 Some Evidence of the Effects of Containerisation

While anecdotal evidence on the effects of containerisation in the business literature may differ enormously in their estimations, the evidence points in the direction of major savings brought about by containerisation. In this section, we look at several pieces of evidence, many of which are taken from Levinson (2006).

A US government sponsored study in 1954 was conducted to investigate the status quo at ports. It was well understood that ports/docks were the bottleneck in the goods transportation system. The subject of the study was a ship traveling between Brooklyn and Bremerhaven in Germany carrying mixed cargo typical to an oceangoing merchant vessel at the time. The ship was loaded and unloaded by longshoremen/dockers, also typical of the time. The researchers had access to detailed information about the cargo and journey.

The ship, the *Warrior*, was loaded with 5000 long tons of cargo, mainly food items, household goods, mail, machine parts and 53 vehicles. Astonishingly, the ship carried 194,582 individual items of every size and description. The goods arrived in the Brooklyn docks in 1156 separate shipments from 151 different US cities, with the first shipment arriving more than a month before scheduled sailing. The items were placed on pallets which were stored in transit sheds. Upon loading, the pallets would be lowered into the hold where the items were removed from the pallets to be stowed using more than $5000 worth of lumber and rope to hold everything in place. The dockers worked one eight-hour shift per day and required 6 calendar days to load the ship. The journey to Germany took 10.5 days and at the German end, it took the dockers 4 days of around the clock work. In other words, the ship spent an equal amount of time to the duration of the voyage docked in port. The last of the cargo arrived at destination 33 days after the ship had docked at Bremerhaven, 44 days after departure from New York, and 95 days after the first cargo was dispatched from its US point of origin.

The total cost of moving the goods by the *Warrior* came to $237,577, not counting the cost of the return trip or time of inventory in transit. The sea voyage accounted for only 11.5% of the costs. Cargo handling at both ends accounted for 36.8%. The researcher concluded that reducing the costs of receiving, storing, and loading the outbound cargo in the US port offered the best method of reducing the total cost of shipping[29].

Trading goods was so expensive that in many cases it did not make any sense to trade internationally. Such was the state of matters in the 1950s and 1960s. Shipping steel pipe from New York to Brazil cost an average of $57 per ton in 1962 (13% of the value of the pipe being exported - this is not including the inland transport cost from the mill to the port). The cost of shipping one truckload of Medicine from Chicago to Nancy (France) in 1960 was $2,386 (14% is the cost of getting freight to US port city, 49% port costs, 24% ocean shipping fees, and around 9% European inland freight)[30].

Five years after containerisation was introduced internationally, McKinsey & Co

[29] Levinson (2006) pages 33-34

[30] Levinson (2006) p. 9, taken from the American Association of Port Authority data.

produced a report on the state of containerisation titled 'Containerisation - A 5-Year Balance Sheet'. The consultancy firm noticed that container movement has spread around the world rapidly. Containers were quickly adopted for land transportation and the reduction in loading time and transshipment cost lowered rates for goods that moved entirely by land[31]. It is no secret that the container along with automation made it possible for companies like Toyota and Honda develop their well-known just-in-time manufacturing strategies. Retailers applied the same strategies to their supply chains with great success (Wal-Mart, Home Depot, etc.).

Time as a trade barrier is well recognised in the trade costs literature. Hummels (2001) found that every additional day in ocean travel reduces the probability of outsourcing manufactures by 1 percent. Also, he found that firms are willing to pay approximately 1 percent more for a shipment for each day saved in ocean shipping.

With the container, the profession of the dockers would become obsolete and labour-intensity of the industry would decline. Shippers can now load their goods directly into a container and have the container transferred to the nearest port either by truck or rail. The process of getting the container onto a ship is now done by specially installed cranes at the terminal. Also the journey of the ship to its destination no longer requires a big crew to take care of shifting loads. So all in all, labour has become only a minor component in shipping. One would expect that labour costs, which made up a substantial part of total shipping costs, have declined due to the introduction of the container.

Labour productivity in UK ports was very low prior to 1966. McKinsey and Company (1967) estimated that for import cargo at a general cargo berth in the UK, a gang of around 26 men is used per ship per shift in 1967. The work rate is usually about 20 freight tons per hatch per hour. For a 5-hatch cargo liner, the discharge rate is usually 100 freight tons per hour using 130 men. Assuming double shifts for 5 days, the total quantity of cargo handled is 8,000 freight tons per week. The number of workers required for the week is 260 men. Output per man, working full shifts without any breaks or lost time, is therefore approximately 30 freight tons, or 0.75 ton per hour (based on an 8-hour shift). As for export cargo, the average output per man hour is 0.625 ton or 25 tons per man week.

[31] Levinson (2006) page 10

In 1967, after the introduction of containerisation, a typical container berth has up to three high-speed container cranes and associated equipment. Assuming a crane cycle of 3 minutes to complete one container discharge/load operation, and a crane availability of 22.5 hours per day, each crane can handle 450 containers each way per day. Maximum output per berth is therefore 1,350 containers per day each way. Labour requirements based on a 3-shift system (to cover for around the clock operation) would be 4 gangs of 36 men each to operate the cranes and handle containers to and from warehouses. This means that theoretically, the weekly output of 144 men is 9,450 containers each way per berth. However, to make a conservative estimation, it is assumed that each berth can only handle 1,800 containers each way per week. The gangs mentioned above can therefore operate on more than one berth. Assume labour utilisation of 40%. This means that 144 men can operate on 2 berths handling a total of 3,600 containers each way per week. An ISO container of 20' has an average cargo of 10 metric tons or 15 freight tons. Allowing for UK trade imbalance (as of 1967), the average cargo per container falls to 12 freight tons. Total cargo handled per week for the 2 berths by 144 men is therefore about 86,000 freight tons. Output per man week is therefore 600 freight tons, or 15 freight tons per man hour. This means that labour productivity will increase by at least 24-fold. This is only the lower-end estimate.

But labour is only part of the story. The approximate time spent at port for a conventional break bulk cargo vessel was 60% of its lifetime before containerisation. About half of that time in port was due to awaiting labour and handling equipment. The container introduced new efficiencies in handling the shipments. The time a ship spends in port has decreased substantially with automisation. This means that ships can spend more time on route earning money. All of the above suggest that shipping costs should have declined since the introduction of the container. The United Nations Conference on Trade and Development (UNCTAD) reported in 1970 that costs of moving freight on containerships were less than half those on conventional ships[32]. However, there is evidence that shipping lines did not pass all the savings on to the customers. Also, shipping prices were subject to cartel agreements (conferences) to ward off competition especially on the North Atlantic routes. It seems that published prices were actually never paid as shippers could negotiate contracts with individual shipping lines.

[32] From Levinson (2006), source:UNCTAD

Besides, just as containerisation was gaining momentum, the world was faced with two main events that had crippling effect on the world economy. On June 5, 1967, Egypt unexpectedly ordered the shut down of the Suez Canal on the day the Six Day War erupted between Israel and its neighbouring states Egypt, Jordan, and Syria. The Canal would stay shut in the face of shipping traffic for exactly 8 years. Ships from Europe were no longer able to take the shortcut through the Suez Canal but had to circle Africa to reach their markets of Asia. Of course, this shock to distance only affected Europe-Asia trade routes. The increase in distance between 1967 and 1975 automatically translates in higher freight rates that could have undone any rate savings brought about by the container. Feyrer (2009) estimates the effects of the closing of the Suez Canal on world trade and income.

In 1973, just as the closure of the Suez Canal was still underway, a second major event occurred. The Yum Kippur War erupted on October 6, 1973 when Syria and Egypt launched an attack on Israel to free land that was captured by Israel during the 1967 Six Day War. The war was fought from October 6 to October 26. On October 16th, Arab oil-exporting countries agreed an oil embargo against the United States and several other states for their support to Israel during the war. The oil crisis would last until March 1974. During the crisis, the price of oil quadrupled in a matter of months. As one would expect, shipping companies had to transfer the increase in their fuel costs to the shippers. Freight rates soared as a result. It seems that these events may have undone any savings the container delivered. Also, many freight rates had to reflect the high inflation that affected industrial countries in the 1970s. Hummels (1999) finds no evidence of a decline in liner shipping prices in the post war era of globalisation (1950 onwards) based on shipping freight indices.

Ocean freight is not the only cost involved in transporting imports and exports. The total freight bill involves not only ship rates, but also land transport to and from ports, packaging, storage and port charges, damage, theft and insurance, and the cost of money tied up in goods that are in transit. These are aspects not included in the freight bill. Containerisation is likely to have affected all of those. This introduces us to the motivation of our research which we discuss in the next chapter.

Chapter 3

Motivation, Research Question, and Literature Review

This chapter raises the research question and motivates the research. We also review the relevant literature. We start the discussion by motivating the research in the first section before we move to discuss what the economics literature says about the research question.

3.1 Motivation and Research Question

Between 1948 and 1993, world trade has grown by an average of 150% annually in nominal terms. In real terms, world trade has grown by an average of around 21% annually between 1962 and 1990. Refer to figures 3.1 and 3.2.

In the decade after 1966 when the container made its international debut, the volume of international trade in manufactured goods grew more than twice as fast as the volume of global manufacturing production, and two and a half times as fast as global economic output (Krugman (1995)). Economic expansion was sluggish in that period and the oil shocks made things worse. Nevertheless, international trade was expanding as the data show. What was driving this acceleration in trade growth?

Krugman (1995) raises the same question. What was driving the growth in international trade after World War II? He realizes that this question remains very much disputed. He identifies two world views. The two views belong to journalists/commentators and professional economists. Most journalistic discussions emphasise the role of techno-

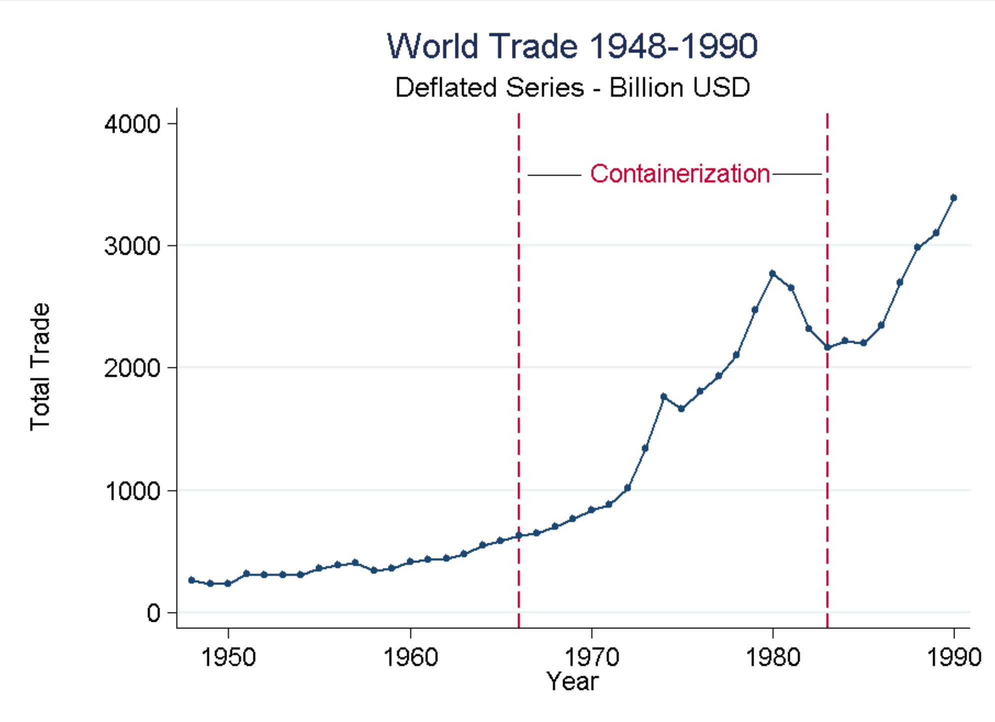

Figure 3.1: World Trade 1948-1990 (Deflated)

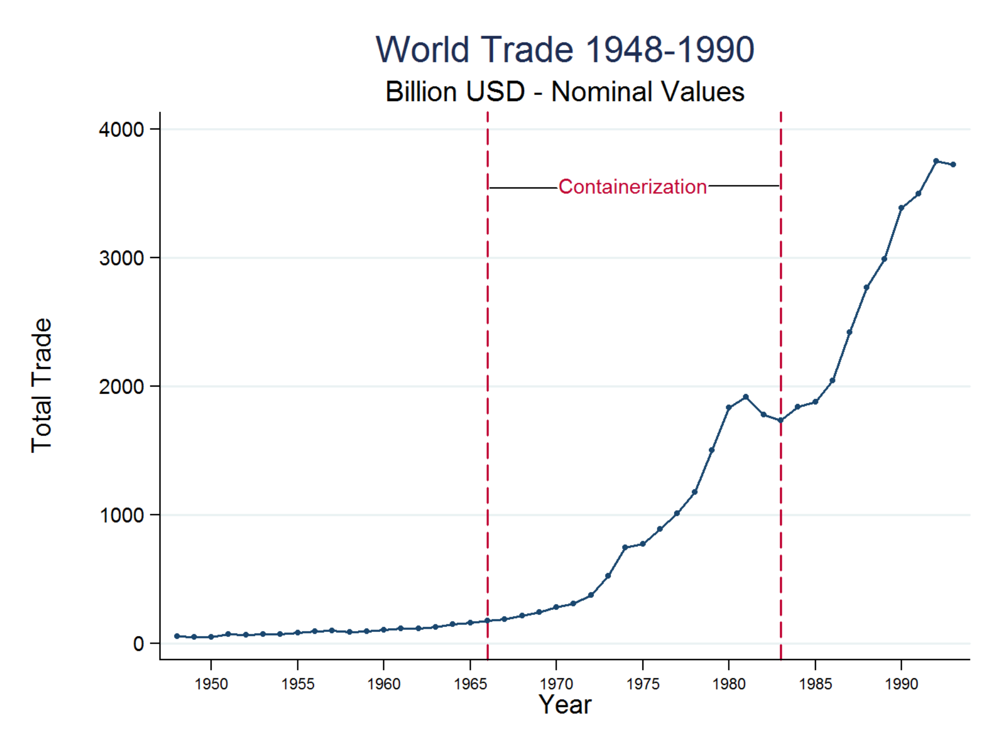

Figure 3.2: World Trade 1948-1990 (Nominal)

logical improvements in transportation and communication as the driving force behind global integration. International economists, however, tend to view much of the growth of trade as a result of the reversal of protectionism that had restricted world markets since 1913. World markets achieved an impressive degree of integration during the second half of the nineteenth century mainly due to the opening of the Suez Canal, the switch to steamships from sail, and railroads. World trade as a share of world output does not recover to its 1913 level until the mid 1970s. Only since the 1970s that growth truly represents a new phase of globalisation and integration, he argues.

Economists make a distinction between two waves of globalisation. The first wave takes place between the 1850s and World War I. This wave was notably marked by the switch from sail to steam in shipping (Harley (1973)) and the introduction of railway (Fogel (1964), Hurd (1975), Donaldson (2008)). The second wave of globalisation starts after World War II. This wave is marked by the switch from break-bulk shipping to containerisation (Hummels (2007)). This is where our research comes. In the early 1990s, it was marked by cheaper air cargo (Harrigan (2010)). Between the two waves/eras, there was a period of reversal of globalisation in which countries reverted to protectionist policies.

While many economic studies explored the effects of the switch from sail to steam and the introduction of the railway/steam train in the first globalisation era, very few studies in the economics literature exist that look at the role of technological progress in the second globalisation era. Despite claims about the significance of containerisation in contributing to the growth of world trade, systematic evidence on the effects of the adoption of container technology on world trade appears to be missing. This is where this research comes to fill the gap. We are mainly concerned with how much containerisation contributed to the second wave of globalisation. Namely, in this thesis, we attempt to estimate the effects of containerisation on international trade. Containerisation is a technological change that arises from shipping goods via containers rather than through the traditional break-bulk method which characterised international shipping since antiquity. Do we find any evidence to support the claims that containerisation made major contributions in promoting international trade in the second era of globalisation?

This research is related to two literatures. The first literature pertains to the empirical estimation of changes in transportation technology. The second related literature pertains to trade costs and its effects on the volume of trade mainly in the framework of the gravity equation which we introduce and discuss here.

In the transportation technology literature, scholars distinguish between two waves of globalisation. The first took place between the second half of the nineteenth century and the eve of World War I while the second commences after World War II and accelerates in the early 1970s as shown in figure 3.1.

The defining features of the first era of globalisation (1850-1913) are the introduction of the steam engine in shipping, the dramatic expansion of the railroad networks, and the telegraph.

Starting with North (1958) who finds evidence of decline in freight rates between 1815 and 1913 of the major (bulk) commodities, he explores possible causes for the decline. Citing technology (switch from sail to steam) as playing a role, North was of the opinion that reasons for this decline lie mainly in the development of external economies which greatly reduce port costs and turn around time, the gradual reorganization of international shipping, and the gradual development of the volume of backhaul freight as the new regions expand in population and income as a result of this new export commodity.

In examining freight rates between 1740 and 1913 - the eve of World War I, Harley (1988) similarly finds evidence for a long decline in freight rates starting in 1850 based on several shipping indices. By the early 1900s, he finds that rates are only about a third of what they were before 1850. In exploring the reasons for this decline, he challenges the findings of North. He conducts a productivity gains calculation on a new freights index. He finds that the switch from sail to steam as metallurgical advances were applied to ocean transport was the main contributor to this decline. The use of metal in building the ship hulls and the steam engines signalled a technological departure from sail ships. The new vessels resulted in strong economies of scale and less factor inputs which resulted in steadily declining freight rates.

Mohammed and Williamson (2003) similarly find evidence for drastic declines in freight rates between 1869 and 1913 by constructing new freight rate indices from previously unused data. They find that rapid technological change drove the decline in real freight rates before World War I and the slow down in technological change contributed to the stability in rates during the interwar period.

The first wave of globalisation was not only characterised by the switch from sail to steam. Another big technological change in that period was the introduction of rail and the steam train. In Britain, which was the pioneer, this took place between 1830 and the 1850s. By the 1850s, Britain had over 7000 miles of railway. In the USA, the years between 1850 and 1890 saw exponential growth in US railroads which at its peak made up one-third of the world total railroad mileage[1].

In the economics literature, railroad and its economic impact received a good deal of attention. Starting with Fogel's (1964) pioneering study on the effects of US railroads on economic growth, a number of studies have investigated the effects of railroad construction on economic performance and market integration.

Hurd (1975) investigates the behaviour of prices of food grains in India from 1861 to 1921 in relation to railway expansion during this period. In comparing food grain prices between Indian districts, the author finds the prices in some districts were eight to ten times higher than the prices in others in the 1860s (before railway). He argues that transportation problems and high transport costs were the reasons for this disparity. Railway expansion in India was very rapid and occurred on a massive scale. In 1910, India had the fourth longest total track mileage in the world ahead of the United Kingdom. With the expansion of the railway system, distant isolated markets were connected and separate markets became part of the same market. By analysing variation in prices, they find that prices of wheat and rice converge between 1870 and 1921 across all districts. The correlation between the decline in price variation and the expansion of railway was clear in the study. He concludes that railway expansion was the main reason behind the convergence in grain prices across India.

Based on detailed archival data from colonial India, Donaldson (2008) provides a comprehensive general equilibrium analysis of the impacts resulting from the expansion of India's railroad network during 1853-1930. By collecting archival data from colonial India, the author estimates the impact of India's vast railroad network. The main findings of the paper can be summarised as follows. Railroads decreased trade costs and interregional price gaps and as consequence stimulated interregional and international trade. Railroads also eliminated the responsiveness of local prices to local productivity shocks but increased the transmission of these shocks between regions. With respect to

[1] Wolmar (2009) page 94.

income, railroads increased the level of real income and decreased the volatility thereof. These results suggest that transportation infrastructure projects can improve welfare signifcantly and the main channel of transmission is trade.

Exploiting spatial dispersion of 19th century grain prices, Keller and Shiue (2008) evaluate the relative impacts of railroad technology (steam trains) versus tariff reductions on market integration in the German Zollverein [2]. Market integration is measured by the differences in wheat prices across markets in Europe. They collect prices in 68 market locations across 5 European countries and 15 different German states. In investigating the effects of the new transport technology, the authors employ pair-specific information on the establishment of rail connections between two markets. The customs union (the German Zollverein) which took over half a century to complete - between 1828 to 1888 - is measured with a 0/1 variable . This is also the case for currency unions, which were introduced gradually in the different German States between 1837 and 1871.

Using time-series variation in the adoption of the technology and institutional policies, they estimate the effects of steam trains, customs union, and common currency on the dispersion of wheat prices. To control for potential endogeneity, they instrument each of the relevant variables with two geographical variables each. They find that both institutional change (currency agreements and customs liberalisations) and the adoption of steam trains were important in increasing the size of the market in 19th century Europe. However, the impact of steam trains is found to be larger than the institutional changes. They estimate that the introduction of steam trains reduced price gaps by about fourteen percentage points; trade liberalisation by about seven percentage points and currency agreements by about six percentage points.

While the introduction of rail and steamships were the main changes in transportation technology that underpinned the first wave of globalisation (1840s-1914) Krugman (1995) raises the question about what was driving the growth in international trade after World War II? As we mentioned in the previous section, he identifies two world views. The first view belongs to journalists who attribute the latest wave of globalisation to technological improvements in transportation and communication. The second view of

[2]The Zollverein, or German Customs Union, was a coalition of German states formed to manage customs and economic policies within their territories. Established in 1818, the original union cemented economic ties between the various Prussian and Hohenzollern territories, and ensured economic contact between the non-contiguous holdings of the Hohenzollern family, which was also the ruling family of Prussia. It expanded between 1820 to 1866 to include most of the German states.

the international economists tends to emphasise the role of bilateral and multilateral trade liberalisation.

Krugman also identifies four new aspects of modern world trade. These are the rise of intra-industry trade or the trade in similar goods between similar countries; the creation of production chains, the breaking of the production process into many geographically separated steps; the emergence of supertraders, countries with extremely high ratios of trade to GDP such as Hong Kong and Singapore; and finally the emergence of large exports of manufactured goods from low-wage to high-wage nations.

Other economists suggested other potential candidates for explaining the rise of international trade. Convergence in economic size was suggested by Helpman (1987) and Hummels and Levinsohn (1995). Yi (2003) suggested the role of vertical specialization/outsourcing in increasing world trade through increasing intermediate and final goods trade.

The answer to Krugman's contentious question is likely to be a combination of all of the above. Baier and Bergstrand (2001) try to disentangle the different potential causes of the growth in international trade. Namely, they disentangle the relative effects of transport-cost reductions, tariff liberalisation, and income convergence on the growth of world trade. They do so for several OECD countries between the late 1950s and 1980s. They find that income growth explains about 67%, tariff-rate reductions about 25%, transport-cost declines about 8%, and income convergence virtually none. This is not necessarily in favour of containerisation.

Jacks et al. (2008) challenge the findings of Baier and Bergstrand (2001) by deriving a measure of aggregate bilateral trade costs based on the structural gravity equation. They find that trade cost declines explain 33% of the trade growth between 1950 and 2000.

Lundgren (1996) finds that bulk freight rates have decreased by about 65% during the period 1950s to the 1980s mainly due to increased economies of scale.

Students of transportation technology and prominent commentators link the post World War II growth of world trade to containerisation. For example, Paul Krugman writes (Krugman (2010), p.7):

> The ability to ship things long distances fairly cheaply has been there since the steamship and the railroad. What was the big bottleneck was getting

> things on and off the ships. A large part of the costs of international trade was taking the cargo off the ship, sorting it out, and dealing with the pilferage that always took place along the way. So, the first big thing that changed was the introduction of the container. When we think about technology that changed the world, we think about glamorous things like the internet. But if you try to figure out what happened to world trade, there is a really strong case to be made that it was the container, which could be hauled off a ship and put onto a truck or a train and moved on. It used to be the case that ports were places with thousands and thousands of longshoremen milling around loading and unloading ships. Now longshoremen are like something out of those science fiction movies in which people have disappeared and been replaced by machines.

Despite claims in the business and transportation literature about the alleged importance of 'containerisation' in stimulating world trade, the trade literature has been surprisingly silent about the impacts of containerisation[3]. Two noteworthy exceptions are Hummels (2007) and Blonigen and Wilson (2007).

Hummels (2007) looks at transportation costs in the second era of globalisation, i.e. the post-war era of trade. Between 1950-2004, world trade grew at a rapid average rate of 5.9% per annum. He investigates the explanations for the rise in international trade. One prominent explanation is the decline in transport costs. The decades since World War II witnessed technological changes in shipping, namely the introduction of the container and the development of the jet engine. However, evidence of decline in shipping costs in recent decades has been lacking.

In the first part of his study, Hummels looks at how goods move in international trade. He finds that roughly 23% of world trade by value occurs between countries that share a border. For trade with non-adjacent partners, nearly all merchandise trade moves via ocean or air modes. However, air cargo remains very limited. Air shipments represent less than one percent of total tons and ton-miles shipped in 2004. Bulk commodities such as oil, iron ores, coal, and grain are shipped almost exclusively by sea. Bulk trade constitutes the majority of international trade when measured in

[3]We draw on the relevant business literature where necessary especially in the narrative section but we will not review this literature here as it is not necessary for our economic analysis

weight, but much smaller and shrinking share of trade in value terms. Manufactured goods are the largest and most rapidly growing portion of world trade.

In looking at changes in transport costs, he examines customs data from New Zealand and the US on shipment freight expenditures. He finds that freight costs exhibit no clear trend in the New Zealand case, meaning no change, and a steady decline in the US data. The New Zealand data cover the period 1963-1997. The US data cover the period 1974-1997. In the US case, costs declines from about 8% of the value of total imports in 1974 down to about 4% in 1997. However, the decline possibly masks shocks to prices due to the oil crisis in 1974. A problem with this measure is that it does not distinguish between bulk, container, or break-bulk shipments. Also, since goods with high transport/freight costs are less traded, then aggregating shipment freight expenditures naturally gives lower weights to these goods.

To answer the question whether technological changes resulted in lower ocean shipping prices, Hummels exploits price indices for tramp (bulk) and liner shipping (container and break-bulk). For liner shipping, the author uses an index constructed by the German Ministry of Transport. The index suggests an actual increase in ocean shipping rates during the time period 1974-84 that coincides with the period of major containerisation. This is also the period of high oil prices. The index includes both general cargo moved as break-bulk and in containers. It is however not clear what percentage of goods is moved in containers. The index is not representative of world shipping prices as it focuses only on shipping lines operating in Germany and the Netherlands. Using commodity data on US trade flows, Hummels finds that freight cost reductions from increasing an exporter's share of containerised trade have been eroded by the increase in fuel costs resulting from the 1970s hike in oil prices. Nevertheless, running regressions to study the determinants of transport costs in the US, he finds that increasing the share of containerised trade lowers shipping costs between 3 to 13%. Hummels (2007) concludes then that "the real gains from containerisation might come from quality changes in transportation services...To the extent that these quality improvements do not show up in measured price indices, the indices understate the value of the technological change".

Building on Clark et al. (2004) in examining the effects of port efficiency measures on bilateral trade flows, Blonigen and Wilson (2007) also estimate the effects of increased container usage on reducing the import charges for US imports during 1991-2003. They find that increasing the share of trade that is containerised by 1 percent lowers shipping costs by only 0.05 percent.

It is perhaps no surprise that the state of infrastructure in a country has a direct effect on trade. Limao and Venables (2001) examine the determinants of transport-cost factors. Using data on shipments from Baltimore, Maryland to various destinations, they found that transport-cost factors were both marginal and fixed cost factors. Marginal costs include distance and borders which have economically and statistically significant effects on transport costs. Regarding fixed trade costs, the higher the quality of infrastructure of both the exporting and importing countries the lower cost. For landlocked countries, the higher the level or quality of infrastructure of the country used for its ocean port the lower the cost. We investigate the effects of allowing landlocked countries to use their rail to ship containers overseas in this thesis.

Another secondary strand of literature that could be linked to our research is the literature of technology change and the effects thereof. Head et al. (2009) investigate whether technological advances in communication leads to imminent offshoring of services and loss of jobs as a result. They provide a model for international services trade that generates a gravity-like equation for services. They find that distance still matters in services trade unlike what other models have suggested. Distance shields workers to a significant extent from the threat of offshoring.

Trade costs, broadly defined, are all the costs that are incurred in shipping a good from a producer to a final user other than the production cost of the good itself. Anderson and van Wincoop (2004) define trade costs as "all costs incurred in getting a good to a final user other than the marginal cost of producing the good itself: transportation cost (both freight and time costs), policy barriers (tariffs and nontariff barriers), information costs, contract enforcement costs, costs associated with the use of different currencies, legal and regulatory costs, and local distribution costs (wholesale and retail)". Traditionally, the literature has focused on protectionist border policies, like tariffs and non-tariff barriers to trade. More recently, the literature has paid more attention to 'natural trade costs', like transportation costs, time or other factors affecting communication (like language, culture).

One strand of the literature examines empirical regularities regarding changes in trade costs over time (Moneta (1959); Hummels (2007)). The other major strand examines the impact of changes in trade costs on trade flows or other performance variables, mostly in the context of an econometric gravity specification. We describe the gravity equation, its origins, and its theoretical foundations below.

Theoretical Foundations of the Gravity Equation

The gravity equation has long been used successfully in empirical economics. It relates bilateral trade flows to GDP, distance, and other factors that determine trade. It has been widely used to estimate the effects of changes in measurable and non-measurable trade costs such as customs and currency unions, language, and border effects (see Bergstrand and Egger (2011) for a good survey). The traditional gravity model is inspired by Newton's Law of Gravitation. A mass (country j) attracts goods (demand E_j) from another mass (country i with supply Y_i) and the potential flow is reduced by the distance between the two masses (d_{ij}). The gravity formula can be written as:

$$X_{ij} = \frac{Y_i E_j}{d_{ij}^2} \tag{3.1}$$

The formula gives the predicted movement of goods between i and j (X_{ij}). The gravity equation was first used by Ravenstein (1889) for migration patterns in the 19th century United Kingdom (UK). Tinbergen (1962) was the first to use gravity to explain trade flows between two regions. Estimating the Newtonian-type gravity for trade flows is considered to be one of the most successful empirical models in Economics. In international trade, the gravity equation surfaced as a statistical model to explain variation in aggregate bilateral trade flows among pairs of countries for cross-sections using Ordinary Least Square (OLS).

The gravity equation however remained without any theoretical foundations to justify its use in Economics until 1979. The first formal general equilibrium based gravity equation was first proposed by Anderson (1979). The model is based on two main assumptions. First, each country is assumed to specialise in the production of its own good. Second, identical Cobb-Douglas preferences are assumed.

Anderson and van Wincoop (2003) expanded the derived gravity equation to the constant elasticity of substitution (CES) case to reflect 'love for variety'. The derived gravity equation suggests that econometric estimation of the empirical gravity equation which incorporates the usual control variables such as income and distance may be biased. Namely, the gravity equation suggests that trade flows between countries i and j do not only depend on trade barriers between the two countries but also on the trade barriers of each of the two countries with the rest of the world. This is what Anderson and van Wincoop (2003) term as multilateral resistances. They define multilateral resistances as the average barrier of two countries to trade with all their partners. Intuitively, the more resistant to trade with all others a region is, the more it is pushed to trade with a given bilateral partner.

Traditionally, economic evaluations of trade costs using the gravity method have ignored the multilateral resistances. The implications of keeping them out econometrically is that any such estimates will suffer from omitted variable bias in so far that the independent variable in question is correlated with the multilateral terms which is almost always the case (the multilateral terms are functions of trade costs - see expressions 2.3 and 2.4 below). Anderson and van Wincoop (2003) demonstrate by deriving a simple gravity equation from a CES utility function and homothetic preferences how ignoring the multilateral resistances can bias the estimations. To demonstrate how omitting the multilateral resistances can bias estimations, they use the example of the border puzzle of McCallum (1995). McCallum found that border matters and the effects of borders are extremely large. Using the traditional gravity equation, he estimates that the US-Canadian border led Canadian provinces to trade 22-fold more than Canadian and US states.

Anderson and van Wincoop found that by ignoring the general equilibrium effects and hence the multilateral resistances, the Canadian-US border reduced international trade by 80%. By applying the theoretically founded gravity equation and accounting for multilateral resistances, the border reduced Canadian-US trade by only 44%.

The gravity equation as derived by Anderson and van Wincoop (2003) looks as follows:

$$X_{ij} = \frac{Y_i E_j}{Y}(\frac{t_{ij}}{P_i P_j})^{1-\sigma} \tag{3.2}$$

The price indices P_i and P_j are the multilateral resistance variables and they depend on all bilateral resistances t_{ij}. Y_i and E_j are income of country i and expenditure of country j relative to world income Y and σ is the elasticity of substitution parameter.

The gravity equation 3.2 tells us that bilateral trade depends on bilateral trade barrier between i and j relative to the product of their multilateral resistance terms, after controlling for size. For a given trade barrier between i and j, higher barriers between j and its other trading partners will reduce the relative price of goods from i and thus raise imports from i.

The key implication of the theoretical gravity equation derived by Anderson and van Wincoop is therefore that trade between countries i and j is determined by the trade barrier between them relative to average trade barriers that both regions face with all their trade partners. The expressions of the multilateral resistance terms are given by:

$$(P_i)^{1-\sigma} = \sum_j (\frac{t_{ij}}{P_j})^{1-\sigma} \frac{E_j}{Y} \tag{3.3}$$

$$(P_j)^{1-\sigma} = \sum_i (\frac{t_{ij}}{P_i})^{1-\sigma} \frac{Y_i}{Y} \tag{3.4}$$

It is clear from equations 3.3 and 3.4 that the multilateral price terms are both functions of trade costs. This is why omitting the multilateral terms from the estimated gravity equation leads to biased estimates. An alternative approach to estimating equations 3.2-3.4 is to estimate equation 3.2 using country-specific FE (exporter- and importer-year FE in the panel setting) to generate unbiased gravity equation parameters.

Anderson and van Wincoop (2004) calculate the bias present in traditional gravity equations that omit the multilateral resistance terms. They also discuss the aggregation bias that arises when estimating gravity with aggregate trade data and recommend using disaggregate product level data.

Anderson (2011) gives a theoretical background into the gravity equation and highlights some of the problems that arise when estimating the structural model. He argues that while gravity has been mostly used to study aggregate bilateral trade flows, the model is more fit to be used for disaggregated goods because the frictions "are more likely to differ markedly by product characteristics". More specifically, aggregation in estimating the traditional model causes two problems. There is aggregation bias because of sectorially varying trade costs and sectorially varying elasticities of trade with respect to costs. Anderson and Yotov (2010b) and Anderson and Yotov (2010a) find evidence of downward bias due to aggregation. The second aggregation problem is specification bias due to the use of GDP in the estimations which is a value-added concept with variable relationship to gross trade flows. The author argues that disaggregation and use of sectorial output and expenditure variables fixes the problems. In this thesis, we will use aggregate trade flows to estimate gravity equations and then move to estimate disaggregate product level models in line with the literature.

Following the derivation of the gravity equation by Anderson (1979), Bergstrand (1985) proposed another general equilibrium theory for the gravity equation derived from 'nested' CES utility function in an endowment economy. He assumes that output by exporter is not costlessly substituted among foreign markets (unlike Anderson (1979)). The exporter is assumed to have a constant elasticity of transformation (CET) production function. The gravity equation derived from these assumptions included multilateral price terms. Therefore, Bergstrand finds that the price indices influenced bilateral trade flows.

Similarly, the gravity equation could also be derived from monopolistic competition, Ricardian, and Heckscher-Ohlin models. Feenstra et al. (2001) find that the different models that are used to derive a gravity-type equation have different implications for the coefficient estimates.

Krugman (1979) assumes a one-sector economy with one factor of production (labour) and CES preferences where each exporter has an endogenous number of varieties of goods to offer. The utility function can be written as:

$$\left(\sum_{i}^{N} n_i c_{ijk}^{(1-\sigma)/\sigma}\right)^{\sigma/(\sigma-1)} \tag{3.5}$$

Maximising equation 3.5 subject to a budget constraint yields a demand function for country i's exports to country j:

$$X_{ij} = n_i \left(\frac{p_i t_{ij}}{P_j}\right)^{1-\sigma} Y_j \tag{3.6}$$

where P_j is the consumer price index of j.

Krugman assumes a monopolistic competitive market structure, increasing returns to scale for the production of the firm, and a single factor of production (labour). Under monopolistic competition, zero economic profits are assumed in equilibrium. This structure is used to derive the gravity equation:

$$X_{ij} = \frac{Y_i Y_j}{Y^w} \frac{(Y_i/L_i)^{-\sigma} t_i j^{1-\sigma}}{\sum_{k=1}^{N} Y_k (Y_k/L_k)^{-\sigma} t_i j^{1-\sigma}} \tag{3.7}$$

where the Y's are income terms, L is labour endowment, and t_{ij} are trade costs between countries i and j.

An alternative approach to the Krugman model focuses on the production side in the Ricardian spirit. Eaton and Kortum (2002) model the trade of a continuum of goods and assume countries have differential access to technology and perfect competition. Allowing CES preferences and Ricardian technology with heterogeneous productivity for each country and good, productivities are randomly drawn from a Frechet distribution. The bilateral trade flows formula derived is similar to equation 3.2 except that instead of sigma, we now have theta, which is the dispersion parameter of the Frechet distribution:

$$X_{ij} = T_i Y_j \frac{(c_i t_{ij})^{-\theta}}{\sum_{k=1}^{N} T_k (c_k t_{kj})^{-\theta}} \tag{3.8}$$

where T_i denotes i's state of technology which influences sales, c_i denotes the unit cost of inputs (labour).

Equations 3.2, 3.7 and 3.8 resemble each other, In all three equations, trade flow from i to j is a function of importer j's overall economic activity and the price of exporter i's output relative to a measure of the overall level of prices of goods facing importer j.

Empirical Applications

Gravity has been used extensively to estimate the impact of many other factors that may affect volume of trade. The number of empirical studies is huge. Since some of the empirical estimations in this thesis include controls for what we call 'policy variables', we will discuss the efforts to isolate the effects of these variables here. The policy variables that we control for are: FTAs, GATT membership, and currency unions.

One of the oldest uses of the gravity equation is to estimate the effects of economic integration such as FTAs and the World Trade Organisation (WTO). In fact, Tinbergen (1962), in the first application of gravity to trade, looked at the effects of membership in the Benelux Free Trade Agreement (FTA) and the British Commonwealth on members' trade.

Early estimations of the effects of FTAs ignored multilateral resistances (Aitken

(1973), Bergstrand (1985)). In the last decade or so, researchers have used panel data to estimate the effects of FTAs. Egger and Pfaffermayr (2003) argue that the proper specication of a panel gravity model should include time invariant country-pair and time FE. This is because country-pair effects account for a large part of the variation. Similarly, Cheng and Wall (2005) demonstrate that estimates are biased when country-pair FE are omitted. In our analysis, we therefore include country-time FE to control for multilateral resistances as well as country-pair to take into account the suggestions made by Egger and Pfaffermayr (2003) and Cheng and Wall (2005).

Several recent studies in the effects of FTAs have consequently incorporated the theoretical and econometric considerations discussed here. One of the most prominent studies is that of Baier and Bergstrand (2007). We review this paper in detail here since we draw on its econometric methodology in this thesis.

Baier and Bergstrand (2007) address econometrically the endogeneity of FTAs. They argue that FTA dummies in the context of gravity are not exogenous random variables. Countries usually select endogenously, perhaps for reasons correlated with the level of trade. If FTAs are endogenous, then previous cross-section empirical estimates of the effects of FTAs on trade flows may be biased. Some attempts have been made to solve the endogeneity problem by using instrumental variables such as Baier and Bergstrand (2002) but the results were mixed. Using an econometric analysis of treatment effects, they estimate the effects of FTAs on bilateral trade flows using panel data at 5-year intervals from 1960 to 2000 for 96 countries. The empirical results in this paper suggest that effects of FTAs using the standard cross-sectional gravity equation are biased. They estimate that traditional estimates of the effects of FTAs on bilateral trade flows have been underestimated by as much as 75-85%. They demonstrate that the most plausible estimates of the average effect of an FTA on bilateral trade flows are obtained using panel data with bilateral fixed and country-time effects or first-differenced panel data with country-time effects. Doing this, they find that an FTA approximately doubles two members' bilateral trade after 10 years.

Using country FE to account for multilateral resistances helps to account for the endogeneity bias created by prices and the influence of FTAs among other countries on the trade from i to j, but it does not correct for the bias introduced if countries select into FTAs. Potential sources of endogeneity bias generally fall under three categories:

omitted variables, simultaneity, and measurement error. They argue that omitted bias is the most important source of endogeneity bias caused by FTA effects using cross-sectional data. Policymakers' decisions to select into an FTA are likely related to the level of trade (relative to its potential level), and not to recent changes in trade levels. Thus, the determinants are likely to be cross-sectional in nature. With panel data, FE and first differencing can be employed to treat endogeneity bias.

As a FE estimation, they estimate an equation with the log bilateral trade flows as the dependent variables using bilateral (ij) FE to account for variation in distance, border, and language along with country-time (it, jt) effects to account for variation in real GDP and multilateral price terms. Their estimation equation becomes:

$$lnX_{ijkt} = \beta_1 + \beta_2 FTA_{ijt} + \theta_{it} + \delta_{jt} + \phi_{ij} + u_{ijkt} \tag{3.9}$$

Based on this specification, they estimate an FTA coefficient of 0.46 which suggests that an FTA increases trade by about an average of 58%. This specification should generate unbiased estimates for the coefficient of the treatment variable FTA. This is less than the estimated coefficient of 0.68 when multilateral resistances are not controlled for.

The authors argue that FTAs are usually phased in slowly and the nature of the 0-1 FTA variable does not reflect this. The 0-1 FTA variable was constructed using the "Date of Entry into Force" of the agreement. Thus it is reasonable to include one or two lagged levels of the FTA dummy ($FTA_{ij,t-1}$ and $FTA_{ij,t-2}$). The results after including the lags reveal that FTA has statistically significant lagged effects on trade flows. The cumulative average treatment effect with one lag is 0.65; with two lags, the total average treatment effect is 0.76. This is equivalent to an increase of trade due to an FTA of around 114%. To test for strict exogeneity, they include a future level of FTA to the estimation equation ($FTA_{ij,t+1}$). If FTA is strictly exogenous, then the lead variable should be uncorrelated with the concurrent trade flow. This is confirmed in their estimation where the coefficient of the lead variable is economically negligible and not significantly different from zero.

Baier and Bergstrand (2007) argue that they expect first-differenced data to provide better estimates of the average treatment effect. This is because the error terms in the

FE model are likely to be serially correlated and this produces an inefficient estimator. This is not the case with the first-differenced estimator. Also, aggregate trade data are likely to be close to unit-root processes. When estimating the first-differenced version of the above equation, they find that cumulative treatment effects without any lags is 0.3; including 1 lagged change in FTA increases the cumulative effect to 0.52 and with 2 lagged variables, this becomes 0.61. This is equivalent to an increase of 84% in trade due to FTAs 10 years after signing. This result is only slightly smaller than the FE estimate above (0.76). Thus FTA essentially doubles the level of members' international trade after 10 years.

We will use a similar econometric methodology in this thesis since the effects containerisation, we argue, are likely to be felt many years after introduction.

Similar in spirit to Baier and Bergstrand (2007) , Baier et al. (2007) use the same technique to find credible effects of various Latin American FTAs on members' trade flows. Baldwin and Taglioni (2007) employ exporter-time, importer-time, and country-pair FE and found smaller effects of EU integration and no effect of Eurozone membership on members' trade.

Rose (2002) uses the gravity equation to answer the question as to whether membership of WTO or its precursor GATT actually increase the member's trade. He estimates a traditional gravity model (i.e. without accounting for multilateral price terms) in a large panel data set covering over fifty years and 175 countries. He tries different FE specifications (year effects, year and country FE, and year and country-pair effects). Rose tries a variable that indicates unilateral and another that indicates bilateral membership in any trade relationship. The search reveals little evidence that countries joining or belonging to the GATT/WTO have increased their trade.

Tomz et al. (2007) criticise the results of Rose (2002) and find that GATT and WTO membership actually increases trade if one accounts for the role of non-member participants. This is because GATT created rights and obligations not only for signing members but also for colonies, newly independent states, and provisional members. They find effects of GATT and WTO on trade that are economically substantial and statistically significant. This paper however does not make any criticism on the empirical strategy in Rose (2002). Rose (2007) responds to the criticisms raised by Tomz et al. (2007).

Similarly, Rose (2005) finds some effect for WTO/GATT membership on trade when using a within estimator to identify those effects. However, similar to most studies, this paper and the above-mentioned studies failed to account for multilateral resistances that is suggested by the structural gravity equation. This means that their findings should not be taken at face value.

Head et al. (2010) in a paper that investigates the erosion of colonial trade linkages estimate a gravity specification that accounts for time-varying importer and exporter effects and dyadic effects. The purpose of the paper is to examine the effect of independence on post-colonial trade. However, one of the controls in their specification is bilateral GATT membership. They find that GATT membership has an economically and statistically significant effect on trade in the magnitude of around 11% to 12%. This result is more credible since it takes into account country time-variant effects that control for multilateral resistances. With respect to the main findings of this paper, the authors find that trade with the coloniser has contracted by about 65% after 4 decades. They also find that trade between two former colonies of the same empire erodes as much as trade with the coloniser.

Rose (2000) started a strand in the literature of estimating the effects of currency unions on trade using the gravity equation. Estimating a traditional gravity equation, he finds that membership in a common currency union increased bilateral trade by 235%. Rose only included year dummies in his gravity estimation. Frankel and Romer (1999) investigate the effects of trade on economic growth. Combining the two studies, Rose and Frankel (2000) estimate the effect that currency union has, via trade, on output per capita. Glick and Rose (2002) use the time-series variation available in a large panel setting to identify the effect of common currency. By using a within estimator (controlling for country-pair effects), they find that joining/leaving a currency union leads to a near doubling/halving of bilateral trade. The drop of the currency variable coefficient from 1.3 to 0.65 when including country-pair FE is rather dramatic and hints that the estimates in Rose (2000) could be biased.

The large size of the effect estimated by Rose (2000) spurred considerable debate and critique. Baldwin (2006) summarised several of the arguments that have been raised to explain the results of Rose. The first obvious problem was omitted variable bias due to the omission of multilateral price terms as we discussed above at length. The second problem is that currency unions in the data set are dominated by small, poor, and open economies. Other concerns are possible model misspecification and potential reverse causality since countries that choose to use common currencies usually already trade a lot with each other.

Rose and Stanley (2005) uses a meta-analysis of 34 (recent) studies into the effect of common currency on trade to investigate the rather diverging estimates of this effect. He concludes that a currency union increases bilateral trade by between 30 and 90%.

Head et al. (2010) estimates an effect that is between 13% and 34% on international trade when accounting for country-time and country-pair effects which control for multilateral resistances. This is on the lower end of the estimate suggested by Rose and Stanley (2005) .

Chapter 4

Data and Constructing the Container Variable

4.1 Introduction: Intermodality of Containerisation

Experts in the transportation and shipping sectors are of the opinion that containerisation's real value is in its intermodality, i.e. its capacity to be used in all transportation modes indiscriminately. Intermodal transport is the term used for allowing goods to be shifted among the three main transport modes with relative ease. Containerisation allowed goods to be transported quickly to and from the port by rail or truck. The standard container can be transported as a trailer on wheels by trucks and lorries or on wagons by trains. In order to benefit the most from containerisation, countries had to link their ports by rail and roads. In fact, one of the reasons why container ports are inhibitively expensive is the need to have the container ports connected to main cities and industrial areas by rail and road. Also containerisation was putting pressure on the existing road networks as trucks have become bigger to transport 20 foot and 40 foot containers.

Standardisation of the container and the handling equipment enables shippers to search for the cheapest possible total transportation route. This caused a realignment of the relative uses of sea, rail, and road modes of transport. Figure 4.1 shows how allowing for interchanging modes of transport leads to considerably cheaper transport. In this figure, (inland) intermodal transport is achieved by allowing trains between major centres and local distribution by road. The local distribution is assumed to be

10% of the rail journey (with a minimum of 20 miles). One observes that trains provide the lowest cost mode of inland transport for journeys above 100 miles. Trains would only operate between major container ports and inland depots. The advantage of road transport is flexibility to operate on any route. But there are usually limitations on the distance that can be covered in road transport (usually relatively small distances)[1].

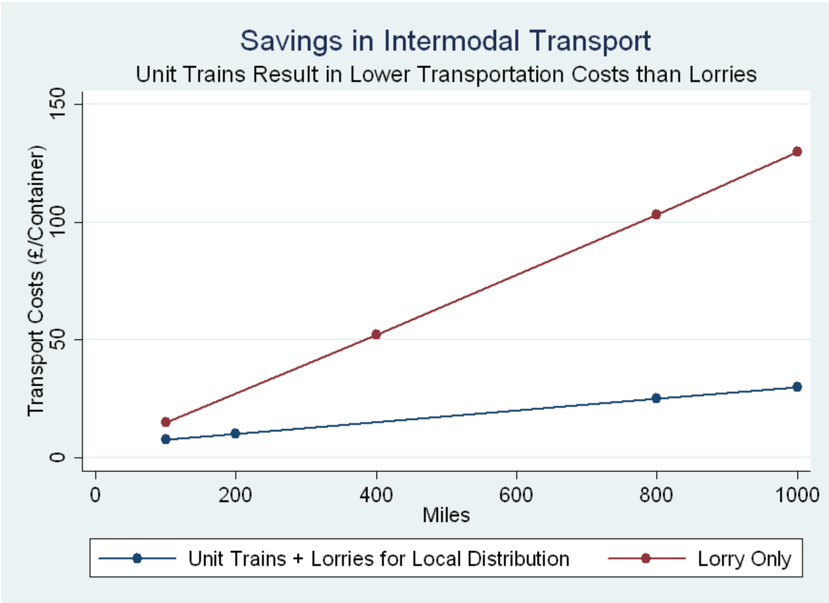

Figure 4.1: Cost Savings in Intermodal Transport in 1967 (reproduced from McKinsey Report)

Intermodal transport does not only occur between inland modes of transport. Unit trains can compete with sea transport on some routes. This is why European Railways were very quick to adopt containerisation on their trains in 1968 (section 2.3.5). Figure 4.2 shows how intermodal transport between sea and rail can be achieved[2]. Costs of transporting containers on rail are always below those of ships with capacity of 600 containers or less. For ships with capacity of 1200 containers, economies of scale are activated and ships become cheaper for trips above 3300 miles. This means that it is cheaper for the UK to export to US East Coast and have the goods transported by rail to the West Coast instead of transporting directly by sea to West Coast (distance between East and West Coasts of the US is around 3000 miles whereas the sea distance via Panama is over 6000 miles). This is what one sees in modern shipping as well where European exports call at East Coast ports in the US and are moved by trains to the West

[1]Source: McKinsey and Company (1967) based on calculation for the UK in 1967
[2]Source: McKinsey and Company (1967), projections for UK trade

coast or the Mid-West. Evidence from this figure and the previous one suggests that sea and rail are likely to be very important for international trade and trucks perhaps more important for internal trade.

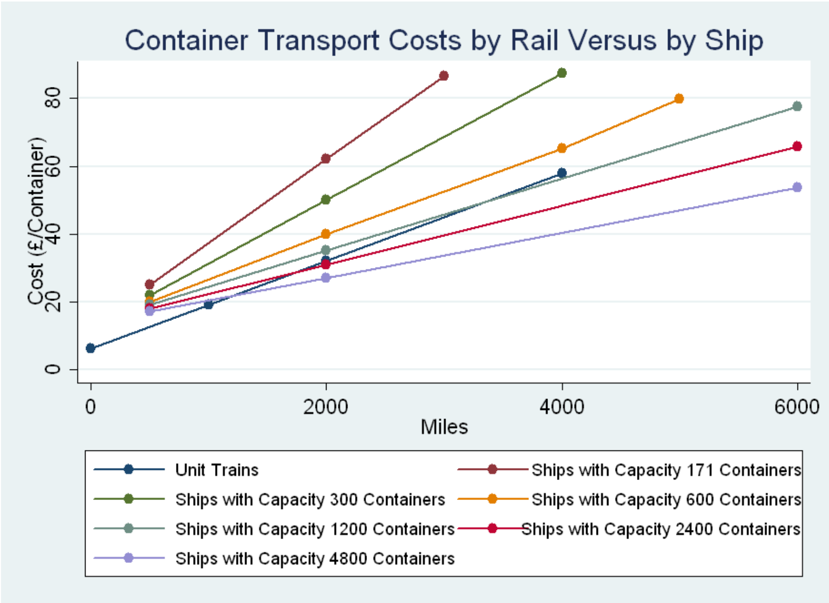

Figure 4.2: Costs of Transporting Containers by Ship Vs Train in 1967 (reproduced from McKinsey Report)

Given the above evidence, we present data on containerisation that take into consideration this rather important feature of containerisation which is its intermodality. The data we present in this chapter however may give a rather incomplete picture about the timing of the adoption of the container. This is because we identify containerisation in ports and rail. We have no information about cargo transport by truck. This is one of the reasons why we consider international trade outcomes in our analysis.

In the countries that could afford to equip their ports to handle containers, we observe that containerisation is a process that mostly starts with the port but quickly progresses to engulf other parts of the transportation network of a country. What we usually see is that ports have to be connected to the road and rail networks to the rest of the country to avoid congestion at the port. Congestion in the port of New York and Manhattan was one of the main reasons why New Jersey was chosen as a location for the new container port.

In section 2 of this chapter, we describe our data sources and construct a measure for port containerisation. In section 3, we present and discuss evidence on the speed of adoption of containerisation in some countries. In section 3, we present our data on railway containerisation. Since containerisation develops into a comprehensive intermodal transport system, and due to the nature of our container measure, we hold a discussion on what we are likely to be capturing with our variable in section 5. In sections 6 and 7, we discuss the data set on trade flows and present some descriptives. Since not all trade can be moved in containers, we describe how we classify products as containerisable/non-containerisable in section 8 and explore trends in the trade data based on this classification in section 9. In section 10, we describe other relevant data to our analysis.

4.2 Quantitative Assessment of Containerisation: Constructing the Port Container Variable

We construct our containerisation variables from data obtained from *Containerisation International Yearbook 1970-1992.* This is a publication dedicated to container shipping. The main purpose of the publication is to offer experts in the transportation industry with the latest information regarding the progress of the new technology as well as technical information about cranes, ships, and ports. *Containerisation International* has been publishing annual yearbooks and periodical publications since 1969 with the sole focus on containerisation. The yearbooks, which we use as our source, publish information about container ports around the world and report statistics on containerised trade passing through them since the start of containerisation.

The published information gives a summary of the state of containerisation in the world. Once a country starts processing containers, the publication names the containerised port and gives information on the facilities that are available in port at the time of adoption. An example of an entry in the publication is given in figure 4.3.

In this entry, we are presented with information on containerisation in New Zealand, namely Auckland. In the case of Auckland, the port has invested in a new container terminal and the port started handling containers in 1971. The information presented include facilities available at the terminal, future plans for expansions/investments, whether the port is connected by rail, and container tonnage moved through the port.

Not all countries invest in new container terminals, however, mainly due to the

Terminal facilities: Enclosed area of 3·64 hectares (9 acres) for container handling and servicing. Two Clark type 512 van carriers; three forklift trucks with spreader attachment; five tractors and twin lift trailers.
Consolidation: 2,500 sq m (27,000 sq ft) of covered shed, 1,765 sq m (19,000 sq ft) enclosed area. Construction of covered depot of 7,430 sq m (80,000 sq ft) is envisaged for the future.
Rail facilities: Area of 1·6 hectares (4 acres). Two tracks of 365 m (1,200 ft). Forklift/straddle operation combined with twin lift trailers to Terminal. No block trains, as such, assembled. During the period June–December 1971 a total of 2,000 containers was moved.
Future plans: Extension of present terminal servicing area by 3 acres. Provision of one new straddle carrier. Extension of ACT service and introduction of four containerships of Farrell Lines.
Investment in unit load/container facilities – $(NZ) 7 million.

Cargo Handling Statistics

Import	*1970*	*1971**	*1972 (estimated)*
Loaded units		989	
Empty units		617	
Total tonnage		19,293	
Export			
Loader units		1,263	
Empty units		324	
Total tonnage		17,751	
Total containers handled		3,271	
Total containerised tonnage		37,044	
Ro-ro			
Tonnage handled at ro-ro berth (inc. containers)	360,136	470,429	500,000

* Terminal operational from 23 June.

Figure 4.3: Container Adoption in Auckland - New Zealand (Source: Containerisation International Yearbook 1973)

high costs of such an investment. For example, in Greece, containerisation started by appointing one or more berths in an existing port - the port of Piraeus. Container berths need to be deepened and equipped with cranes to handle containers. In figure 4.4, the container entry for Greece suggests that only two berths have specialised for containers in the port and several cranes are available to handle containers. This port started handling containers in 1970 and we have statistics on container tonnage through port.

Hence, we observe different degrees of adoption in ports. The highest degree would be to build a container port from scratch such as Tilbury and Felixstowe in the UK. A lesser degree of adoption would be to build a container terminal in an existing port such as Rotterdam. The least degree would be to make some adjustments on existing berths to make them suitable for containers and add cranes to handle containers such

PIRAEUS

Piraeus Port Authority,
Piraeus
Tel: 426 981

Berths and craneage: Two container berths, total quay length 400 m (1,312 ft), water depth 10 m (32·8 ft). Three floating cranes. Two ro-ro berths, quay length 50 m (164 ft), water depth 10 m (32·8 ft).

Services: *Deep-sea:* AEL, Zim Lines, Prudential-Grace Lines. *Short-sea:* Andrea Merzarios, Mini Lines.

Terminal facilities: 100,000 sq m (1,076,000 sq ft) parking area for containers. Three mobile cranes (Coles and Lorain), one Owen straddle carrier, two Yale forklift trucks, eight Volvo terminal tractors, 17 trailers.

Cargo Handling Statistics*

	1970	1971	1972 (estimated)
Import			
Loaded units	5,600	9,000	
Empty units	400	500	
Total tonnage	60,000	10,000	14,000
Export			
Loaded units	3,000	4,500	
Empty units	2,900	4,800	
Total tonnage	40,000	65,000	80,000
Total containers handled	12,000	18,000	24,000
Total containerised tonnage	100,000	165,000	22,000
Tonnage handled at ro-ro berth exc. containers		25,000	60,000

**approximate figures*

Figure 4.4: Container Adoption in Piraeus - Greece (Source: Containerisation International Yearbook 1973)

as in Greece.

The source of the information reported by *Containerisation International* is the ports themselves. The publication only reports on ports that have facilities to handle containers. Ports that lack container berths (the minimum) are not considered container ports. The information on facilities and container tonnage through ports is not comprehensive and can vary greatly in reliability. Since the source of the information is the ports themselves, ports do not report the same information in all years and some ports are inconsistent in their reporting over the years. This makes it extremely difficult to reconcile the data or information on the facilities available at each port. This is one of the reasons why we choose the qualitative variable approach. Future research could look at ways how we could improve the measure of containerisation.

We observe that many countries containerise gradually with only one or two ports adopting the technology. Most countries add more container ports in subsequent years, perhaps to accommodate increasing container trade. The United States, the United Kingdom, and other large countries are an exception to this as many ports were equipped simultaneously to handle containers.

In constructing our container measure, we consider a country to have adopted containerisation in ports once at least one port is equipped to handle containers. Based on the data described above, we construct country specific (port) containerisation indicator variables. We call this the port container variable since it is specific to ports. Recall that containerisation is an intermodal transportation system that affects all modes of transport. Later in this chapter, we discuss containerisation on the rail. A country-specific container variable switches from 0 to 1 when at least 1 port in that country has started processing containers. This makes our container variable country-time variant (it).

For example, we know that the UK started processing containers when Sea-Land's *Fairland* called at the port of Grangemounth in Scotland in one of the first container services on the North Atlantic route. From there, containerisation gained momentum in the UK. In the case of the UK, our container dummy would switch to one in 1966 and remains on thereafter. The US had been experimenting with container shipping for over a decade when the first containerships sailed to Europe from the East Coast. The US container services were on domestic routes, however, including the West Coast-Hawaii and East Coast-Puerto Rico routes. Since the first containerships to carry US goods to foreign markets sailed in 1966, containerisation of US trade started in that year. Similar to the UK, the US container dummy switches to 1 in 1966.

After identifying the year of adoption for the countries that have adopted containers, we find that the introduction of container ports - outside the innovation country of the US - occurred exclusively between 1966 and 1983. Fortunately, the container adoption period 1966-1983 preceded the period of international airline deregulations of the early 1990s which -in tandem with aircraft innovations- resulted in dramatic reductions in the costs of air transport[3]. This provides a cleaner environment for our analysis.

After constructing the port container measure for the countries that adopt containerisation by 1990, we find that the number of countries that port-containerise between 1966 and 1983 are 119. Figure 4.5 shows the timeline of port containerisation for these countries.

There is clear variation in cross-section and time in the adoption of containerisation

[3]Harrigan (2010); Hummels (1999)

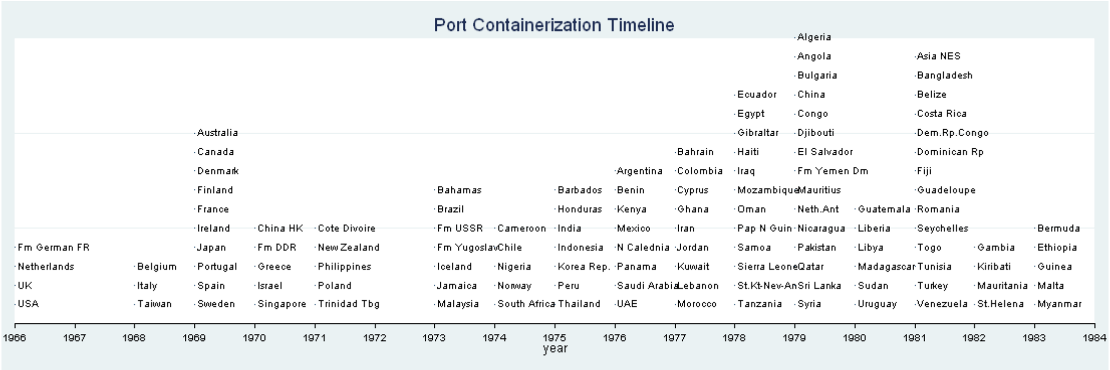

Figure 4.5: Port Containerisation Timeline by Country

around the world. Our analysis will take advantage of this variation in identifying the effects of containerisation.

Our port container measure therefore allows us to identify whether a country in a given bilateral trade relationship has adopted containerisation. It is worth mentioning that at the start of containerisation, only a handful of countries were equipped to handle containers. Shipping lines had to install carry-on cranes onboard containerships[4]. This way, ships could call at ports that are not equipped with special cranes to handle containers. This was necessary in the beginning to give containerisation time to advance and mature. With time, onboard cranes became obsolete as more countries entered containerisation. We mention this here because in the next chapter, we introduce container variables for the originator and destination countries in some of the estimations.

From the timeline, we can see that containerisation was exclusive to developed countries in the early years (with the exception of a few countries). However, the bulk of the countries containerised in late 1970s. This is due to the fact that containerisation requires very high capital investments that may not be readily available for many developing countries. Also, this could be because it is the developed countries that trade the most in 'containerisable' products. To get a clearer picture about containerisation by income group, we show the timeline for each income group separately.

We classify containerising countries as high-income, mid-income, or low-income. To classify the countries according to their income, we use GDP per capita data from the Penn World Tables for the year 1962. We regard a country as high-income if its income (GDP per capita) falls in the top 75% percentile as of 1962, low-income if they fall in

[4] Levinson (2006) pages 56 and 132

the lowest 25% percentile, and mid-income if they fall in between.

Figure 4.6 illustrates the timeline for containerisation of high-income countries. The first countries to adopt containerisation are perhaps unsurprisingly also the richest countries.

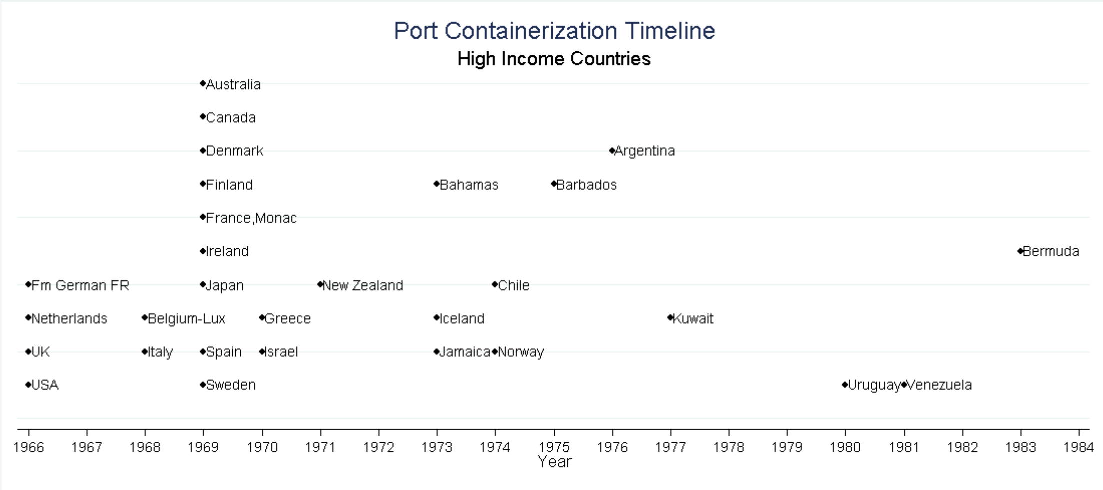

Figure 4.6: Containerisation Timeline - High Income Countries

Mid-income countries don't portray a clear pattern in their containerisation. Figure 4.7 shows that mid-income countries containerised between 1968 and 1983. However, the bulk of these countries in this category containerise in the late 1970s and early 1980s.

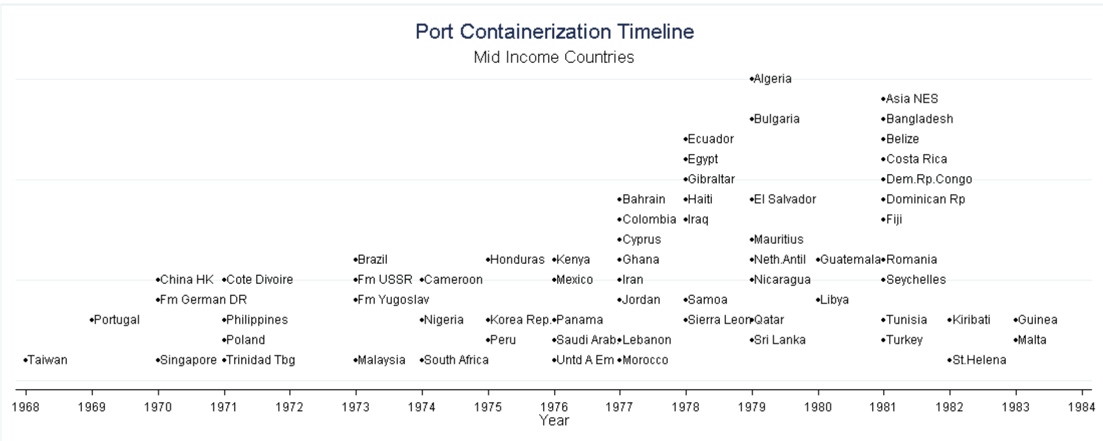

Figure 4.7: Containerisation Timeline - Middle Income Countries

As for low-income countries, they started containerising in 1975 (figure 4.8) . Based on this, the world's most developed countries containerised first. Low-income countries adopted the new technology last. Most mid-income countries started their switch to containerisation after developed countries had already containerised.

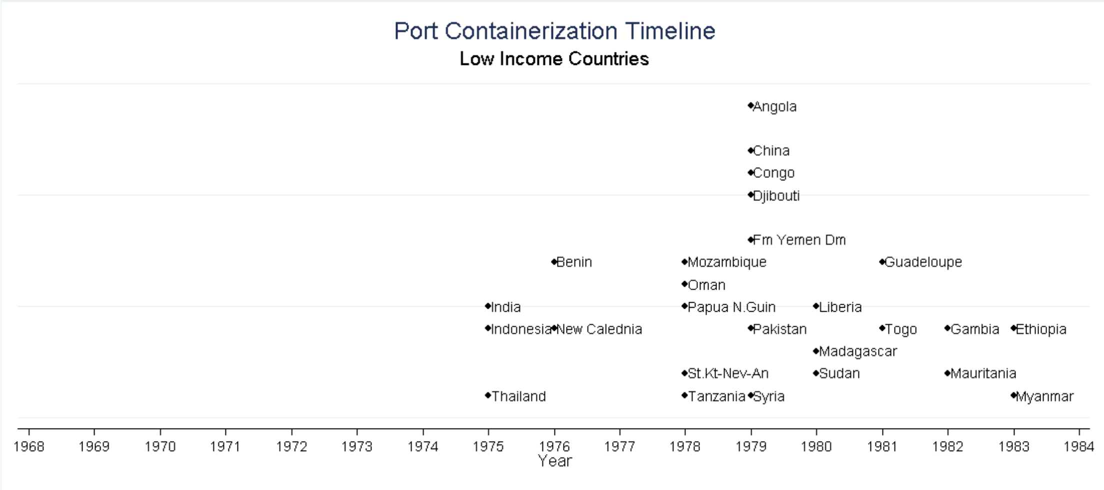

Figure 4.8: Containerisation Timeline - Low Income Countries

4.3 Speed of Adjustment

The use of a zero-one indicator assumes that once containerisation started, the switch to containerisation was instantaneous. This means that all trade that can be moved in containers was moved in containers upon introduction. This is implausible. However, evidence on the speed of adoption is difficult to generate.

In order to construct a measure of speed of adoption, we need information on containerised trade going through ports and total containerisable trade in each country. We define the degree of containerisation in a given year as containerised trade going through ports in a given country divided by total containerisable trade conducted by a country.

Since the data on containerised trade handled in ports is available in tonnage (from Containerisation International Yearbook), we need to collect data on total containerisable trade in tonnage too for each country. Containerisable trade is the trade in goods that can be moved in containers. For instance, shoes are containerisable whereas natural gas isn't. We discuss the containerisability of products in detail in section 4.8. The only source that has information on trade in tonnage (weight) for some countries is the Organisation for Economic Co-operation and Development (OECD) Commodity Trade[5]. Also, since the data we collected from Containerisation International is for ports only, we had to limit our calculations to countries that trade mainly by sea. This is because other OECD countries such as France and Germany conduct a big percentage of their

[5]http://www.oecd-ilibrary.org/trade/data/international-trade-by-commodity-statistics_itcs-data-en (OECD)

trade with their neighbours by land. The most obvious country that meets the criteria is the UK since it is an island country. The UK trades almost solely by sea. Figure 4.9 shows that almost 99% of UK trade went by ship between 1965 and 1979 whereas only very little trade travelled by land or air[6]. Given this, the UK would be the model country. Also for availability of data, we make a similar calculation for the speed of containerisation in Japan.

In figure 4.10 we plot the degree or speed of adoption calculated for the UK and Japan. The UK started containerising in 1966. The degree of containerisation in the UK ranges between around 10% in 1967 to around 80% by 1973. Japan started containerisation in 1969, and by 1970, 20% of containerisable goods traded were being transported in containers. Five years after the start of containerisation, around 60% of Japan's containerisable trade was being moved in containers. The two countries portray similar speed of adjustment to containerisation. Five years into containerisation, more than half of the containerisable trade in being moved in containers.

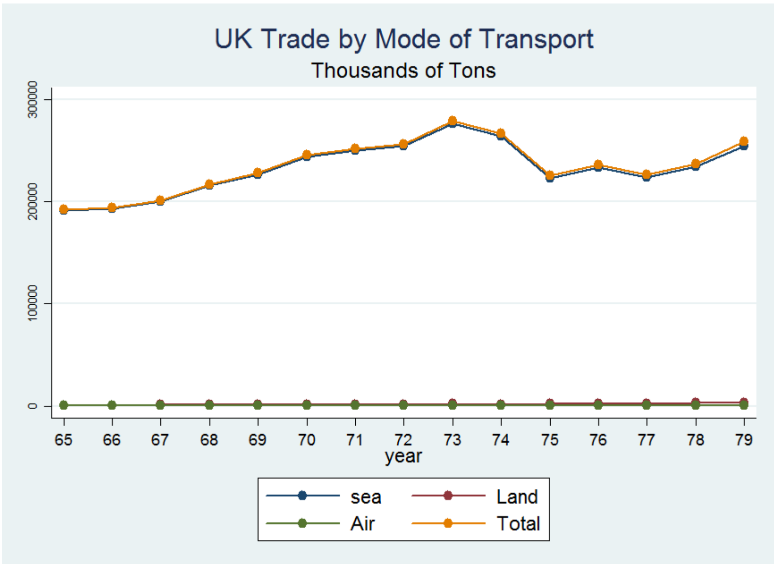

Figure 4.9: UK Trade by Mode of Transport 1965-1979

Based on the evidence, and to mitigate the effect of differences in the speed of adoption as well as to allow trade to adjust to the new technology, we identify the effect of containerisation at 5-yearly intervals in some of the empirical exercises in ensuing chapters. In doing so, we therefore assume that much of the adoption process of con-

[6]Source: Graph produced by author based on data taken from Digest of Port Statistics published by UK National Ports Association (National Ports Council)

tainerisation is complete within 5-years of the adoption. But we will also relax this assumption in some other exercises and examine lagged effects of containerisation in chapter 7.

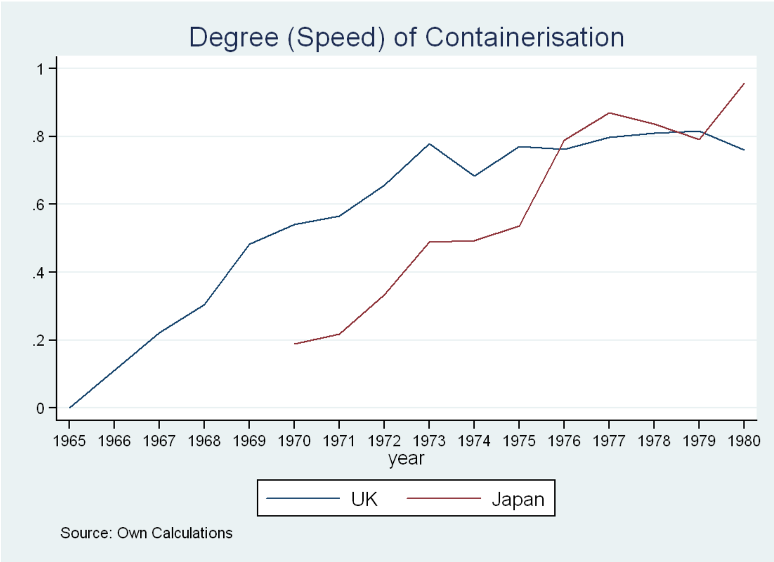

Figure 4.10: Degree or Speed of Containerisation in the UK and Japan

To get a feel for how much was being traded in containers in the early years of containerisation, we plot containerised tonnage for several countries on which we have data. In figure 4.11, we plot containerised trade in tonnage for the USA, Japan, and the UK between 1967 and 1979. Containerisation witnessed very rapid growth in the UK registering an increase in tonnage of almost 9-fold between 1967 and 1979. This is compared to an increase of only 33% in UK total trade other than fuels (tonnage) over the same period. The rapid progress of containerisation is not unique to the UK. In the USA and Japan, container tonnage increased 4- and 9-fold respectively between 1970 and 1980.

Also in smaller countries - some of which are developing countries at the time, containerisation tonnage witnessed rapid growth. In figure 4.12, we plot containerised tonnage for Belgium, the Netherlands, Hong Kong, and Singapore. Containerised trade tonnage increases 4-fold in Belgium, 5-fold in the Netherlands, 25-fold in Hong Kong, and a staggering 300-fold in Singapore between 1970 and 1980. Interestingly, Hong Kong and Singapore became major maritime centres in what is known as hubs and spokes systems. This suggests that containerisation gained popularity among shippers and shipping lines alike very quickly in these countries.

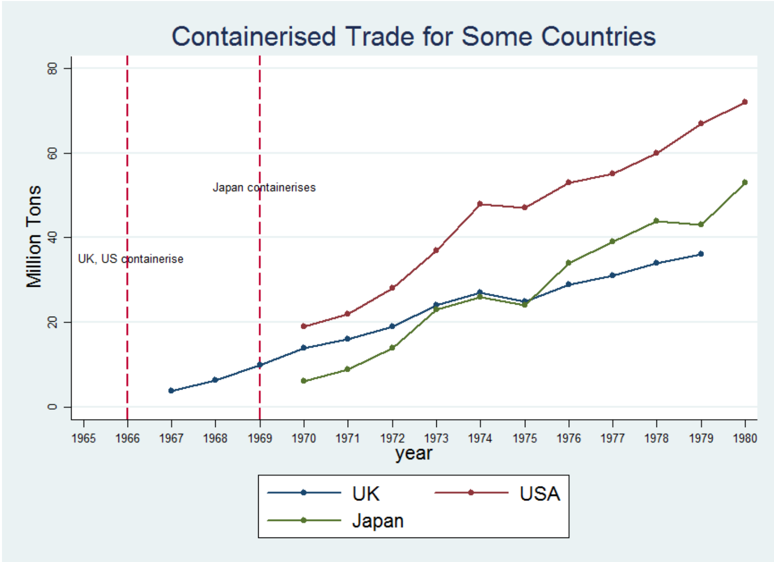

Figure 4.11: Containerised Tonnage in Some Countries

4.4 Intermodality and Railway Containerisation

As we have discussed in the introduction of this chapter, containerisation was not exclusive to ports. Railways were especially keen on capturing some of the container cargo, probably more so in Europe. Being able to carry containers meant that they can compete with shipping lines as a viable means of transport of goods in the new age of the container. They could also compete with trucking companies for inland transport to and from the port (figure 4.1). Many countries saw railways in a race against the clock to build inland container terminals and depots to process containers over the rail. In the UK, British Railways were very quick to adopt the new technology. They started transporting containers on what is known as unit trains very early in the process in 1966, the year that the first containers made their way to the UK by ship[7]. British railways adapted their tracks and trains to containerisation on several routes, built inland depots for processing containers, and commissioned their own shuttle ships to get the containers to mainland Europe.

Upon the British experiment, the railways of Europe came together to coordinate and facilitate the transportation of containers between European countries. Intercontainer, the European association for container transport by rail, saw themselves as competing with shipping lines for intra-European trade. This is due to the nature of European

[7]Containerisation International Yearbook 1973 page 58

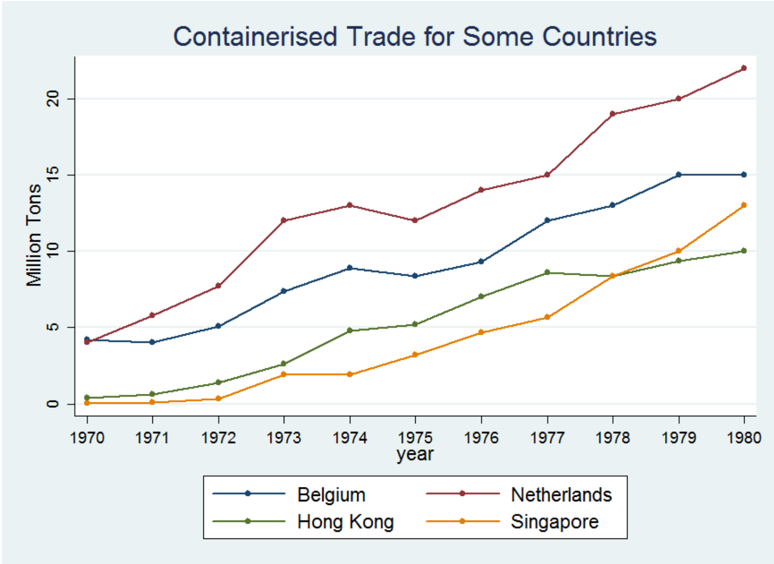

Figure 4.12: Containerised Tonnage in Some Countries

geography. Containers can be shipped by sea between France and Scandinavia. But Intercontainer saw itself as a viable alternative to sea shipping in intra-European trade[8]. McKinsey calculates that moving containers by train can be cheaper than shipping them by sea on shorter routes (figure 3.2). Intercontainer advocated the building of terminals and depots all over Europe to allow for containerisation on rail.

In a similar fashion to port containerisation, we gather information about when countries started using containers in railways. In Europe, this happened almost concurrently in all countries due to the establishment of the Intercontainer system in 1968. In other countries, railway containerisation came as a development to support in transporting containers to and from ports. Containerisation International Yearbook, the source of our information, reported data on railway containerisation by devoting a separate section about railways in each yearbook. The publication also reports whether each of the container ports were connected by rail to the rest of the country (figures 3.3 and 3.4). Based on this information, we are able to identify when containers are being carried on trains in the countries that invest in railways. In figure 3.13, we trace railway containerisation adoption in many countries that invested to move containers by rail.

One striking case in figure 3.13 is India. In India, the story was different to Europe. Government and ports were not quick to containerise. Indian ports started processing containers in 1975. Indian railways, however, were very quick to adopt the new

[8]Containerisation International Yearbook 1972 page 168

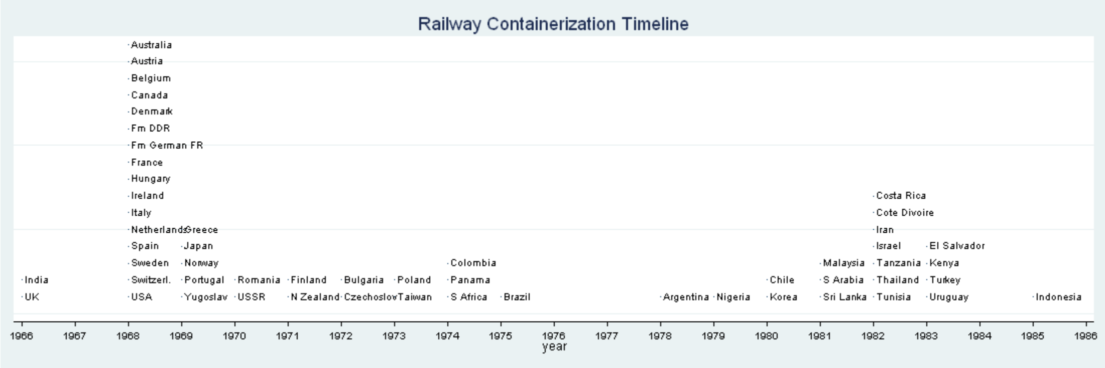

Figure 4.13: Railway Containerisation Per Country

concept. This is probably due to the comprehensive railway system that India already possessed[9]. It is also known that India was a closed economy in the 1960s and there was not an immediate need for port containerisation, therefore. India started building inland container facilities in 1966. They saw in containerisation a way to transport goods between the different provinces and states. Most countries witnessed an improvement in their transport infrastructure after their ports had started containerising. It is obvious that railway containerisation is contingent on an existing comprehensive railway system. In the ensuing chapter we will incorporate this information in studying the effects of containerisation.

Our data thus covers two of the three main modes of cargo transport: port and rail. Our data does not cover roads and is therefore limited since we are not able to capture containerisation on the roads. If we combine port and rail containerisation to allow for intermodal transport between the two modes of transport, we identify the time of containerisation of the different countries whether in port or on rail. We call this 'full containerisation' in this thesis. An obvious advantage of the merged measure is that we allow landlocked countries such as Austria and Switzerland to adopt containerisation by rail and move containers overseas through neighbouring countries. Another advantage is that we allow some countries that did not invest in container ports early on to use their neighbours' ports to shift containers. An example was Norway which delayed its investment in container facilities because it could easily move containers by rail to Gothenburg in Sweden where there is a major container port since 1969. Figure 3.14 combines the information in figures 3.5 and 3.13 and reports the timeline of full

[9]For a good historical and economics study of India's railway, refer to Donaldson (2008)

containerisation in the world. The asterix next to some countries indicated that these countries containerised by rail first rather than in ports.

		Australia*											Algeria				
		Austria*											Angola		Asia NES		
		Belgium										Ecuador	China		Bangladesh		
		Canada*										Egypt	Congo		Belize		
		Denmark*										Gibraltar	Djibouti		Costa Rica		
		Fm German DR*										Haiti	El Salvador		Dem.Rp.Congo		
		France*									Bahrain	Iraq	Fm Yemen Dm		Dominican Rp		
		Hungary*								Argentina	Cyprus	Mozamb.	Mauritius		Fiji		
		Ireland*		HK SAR				Cameroon	Barbados	Benin	Ghana	Oman	Neth.Ant.	Guatemal	Guadeloupe		
Fm German FR		Italy	Finland	Fm USSR*	Cote Divoire		Bahamas	Chile	Honduras	Kenya	Iran	Papua N.G	Nicaragua	Liberia	Seychelles		Bermuda
India*		Spain*	Fm Yugos*	Greece	New Zealand		Brazil	Colombia*	Indonesia	Mexico	Jordan	Samoa	Pakistan	Libya	Togo	Gambia	Ethiopia
Netherlands		Sweden*	Japan	Israel	Philippines		Iceland	Nigeria	Korea Rep	N Caledni	Kuwait	Sierra Leo	Qatar	Madagasc	Tunisia	Kiribati	Guinea
UK		Switzerl*	Norway*	Romania*	Poland	Bulgaria*	Jamaica	Panama*	Peru	S. Arabia	Lebanon	St.Kt-Nev	Sri Lanka	Sudan	Turkey	Mauritani	Malta
USA		Taiwan	Portugal	Singapore	Trinidad	Czechosl*	Malaysia	South Afric	Thailand	UAE	Morocco	Tanzania	Syria	Uruguay	Venezuel	St.Helena	Myanmar
1966	**1967**	**1968**	**1969**	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**

Figure 4.14: Full Containerisation Timeline

4.5 Discussion on the Container variable and what it is capturing

We measure containerisation with a binary variable to indicate that a country started handling containers in ports or by rail. Since containerisation is an integrated system of transportation, our measure captures many aspects that characterised containerisation. In part of the analysis, we choose data points which are 5 years apart to allow for adjustment to containerisation. The result is that we develop a measure that is in effect a proxy for the integrated transportation system that resulted in many qualitative and quantitative improvements in shipping. Some of the savings were direct (labour costs) and some indirect (inventory costs of goods in transit). We list here the most important savings/improvements induced by the container and that are likely to be captured by our container measures.

1. Reductions in pilferage, damage, and theft

   Before the container, it was usual that goods would go missing on the docks while awaiting loading or delivery. Dockers also used this as a means of retaliation against management decisions if these were unfavourable to them. They would be taking home what they thought was their right. The joke on New York piers was that dockers' wages were 'twenty dollars a day and all the Scotch you could carry home'. Also, it was not unusual that goods are damaged in the process of loading and offloading owing to the manual nature of the job. Goods were subjected to multiple handlings from origin to their destination. This increased the probability of getting damaged on the way. The container came to solve these problems for goods that move in containers. Goods are only handled twice now; once when loading the goods in the container on site by the shipper and once when emptying the container by the recipient. This reduced both pilferage and damage.

2. Savings in insurance premia

   The reduction in pilferage and damage claims resulted in reductions in insurance premia. McKinsey and Company (1972) reports that claims paid in 1972 were running at only 15% of their level before containerisation.

3. Improved Port efficiencies

   The nonstandard characteristics of general cargo transport were the main source of inefficiency in the port industry. They resulted in the employment of a large labour force that was poorly utilised. The large number of small units of cargo demanded individual handling. The wide variety of sizes and shapes did not allow effective mechanisation in the industry. Also, the large number of separate origins and destinations required extensive rehandling and sorting for forwarding. This in turn led to wide fluctuations in work load and aided in the poor labour productivity.

   The productivity of the berth is thus linked to that of the labour working on it. There is a practical limit to the number of men working simultaneously on any ship or berth. Prior to the container, general cargo berths were not usually worked around the clock. In many case, labour refused working in shifts. This had resulted in very low utilisation of the assets (berths).

   Using new methods, such as high-speed cranes with small crews, labour productivity increased by more than a factor of 20 as estimated by McKinsey and Company (1967). The productivity of general cargo berths were to increase from the present average of 100k-150k annual tons to 2 million tons per year. The new efficiencies were achieved by:

   - Transferring several functions away from ports such as the sorting depots, customs, warehousing etc.

- Implementing new methods of high-speed loading and discharging (cranes).
- Avoiding congestion by rapid transit of containers away from the port area by unit trains and trucks.

Efficiency of the ports is critical for achieving low-cost shipping. The large capital investment represented by the ship was being poorly utilised in the past. Lack of efficiency resulted in very long ship turnover times and consequently ships spent the majority of the time being idle in ports. Even on many long distance routes such as the UK/New Zealand, ships spent over 50% of their life in port (McKinsey and Company (1967)) .

Another channel through which port efficiency was improved was the separation of container trade from all other trade. Wheat bales are no longer mixed with coffee bags and baskets of fruit. The picture on the docks changed radically. Bulk trade and non-containerisable general cargo is now separate from goods that fit in containers. Most ports transformed some berths to handle pure container cargo and some ports opted to build container terminals from scratch.

4. Intermodal Transportation

This is perhaps the single most important element of containerisation. Industry experts were of the opinion that the true value of containerisation is its intermodality (Donovan (2004); McKinsey and Company (1967)). A container can be transported by truck, rail, and ship from origin to destination and the shift between the three modes can be done effortlessly and cheaply. Low-cost intermodal transfer makes it economic to switch modes to take advantage of the lowest cost alternative.

This intermodality allowed for new patterns of trade. A manufacturer shipping machines from Chicago to Korea is indifferent as to whether the goods went by truck to Long Beach or by rail to Seattle, much less whether the goods entered Korea at Busan or Inchon. Imports for Scotland may be moved there on train from southeast England. Intermodality of the container gave shippers and shipping lines room to choose the best combination of land and sea transport that would minimise the total cost per box. Refer to the introduction for a discussion on intermodality.

5. Time savings

   Before containerisation, it took close to a week to work a medium-sized break-bulk ship. This was mainly due to poor productivity in ports as outlined above in the item about port efficiency. It took two gangs of some twenty-plus men to load/offload a ship. Business commentators observed that a ship would spend most of its time in port instead of voyaging transporting goods and making money.

   With the container, crates and bags of goods are no longer pushed and jerked in place by dockers to utilise space in the holds of ships. The ship would be turned-around in less than 24-hours a day. McKinsey and Company (1972) estimates that the percentage of a ship's life in port dropped from 75% to less than 20% on the North Atlantic route due to the onset of containerisation. Annual voyages were to go up 3-fold as a result.

6. Inventory costs

   McKinsey and Company (1972) in their 5-year review about containerisation report that ships traveling between Europe and Australia had previously spent weeks calling at any of the eleven European ports before making the trip South. Containerships, on the other hand, collect cargo only at the huge container ports (Rotterdam, Felixstowe, Hamburg). Previously, shipments took a minimum of 70 days to get from Hamburg to Sydney, with each additional port call adding to the time. Containerships now travel between the two continents in 34 days, eliminating at least 36 days worth of carrying inventory that is held up in transit. Insurance claims for Europe-Australia service were 85% lower than before containerisation as a result.

7. Labour costs / Union Powers

   Poor labour productivity and frequent strikes affected the entire shipping industry. Labour was a contentious issue in shipping. Management-labour relations were mostly hostile. Ports like New York were crippled by labour strikes. Labour unions were so strong in Europe and the United States that they dictated work conditions on the docks. Even absurd practices such as the welt - a practice under which half of each gang would leave work often to the nearest pub and then an hour or two later the other half would alternate with the first half - was very difficult to eliminate. On the United States' Pacific coast, one formal rule provided that a trucker delivering palletised cargo to a pier would have to remove each item from the pallet and place it on the dock only to be put back on a pallet later by the dockers for lowering into the ship where it is removed again from the pallet[10]. All of this resulted in highly inefficient working conditions and high trade costs. Containerisation came to break the power of dockers' unions albeit perhaps not immediately. The new technology redefined the profession of the docker or stevedore. Large gangs of dockers are no longer needed to work a ship. Only a few dockers are now needed to work one ship and their work is no longer physical. They are mostly operating cranes or driving forklifts and machines to drive containers to and from the docks. Potential savings on labour costs are not exclusive to trade that moves in containers as dockers are no longer needed to sort out mixed cargo in the holds. Ships can now specialise in either bulk or container cargo and loading/offloading cargo is no longer as labour intensive.

8. Economies of Scale

   Economies of scale could be achieved in many of the parts that make up the integrated container system. In ports, economies of scale can be achieved from the high utilisation of port facilities. McKinsey and Company (1967) estimated that port costs can be as low as 3 per container - from 15 per equivalent container load before containerisation - when annual throughput of the berth is about 2 million tons.

   In shipping, conventional ports were the limiting factor of the size of general cargo vessels. Berths could accommodate ships up to certain size and depth. But also, doubling a cargo ship's capacity would almost double its time in port with break-bulk technology. McKinsey and Company (1972) estimated that vessels were able only to grow in size by 14% during the period 1950-1966. Compare that with tanker sizes which grew by 82% during the same period.

   The improved efficiency in cargo handling due to containerisation allowed for larger ships. With no constraints on size, containerships doubled in size and capacity between 1968 and 1972. As ships got bigger, ports got bigger too. New York

[10] Levinson (2006) page 107

handled 7 times more containers in 1980 than in 1970. Also, port facilities could be used more intensively. Under such conditions, the reduction in dock labour requirements was dramatic. McKinsey reported massive improvements in labour productivity on container berths; 30 tons per man hour versus only 1.7 tons per man hour for a conventional berth (McKinsey and Company (1972)).

McKinsey also calculates that as capacity of ships increases from 300 to 5000 containers, per ton cost drops by over 50% for a 5000 miles voyage (one way). This includes cost of ports, ships, containers, and cargo in transit (capital and operating costs). The longer the trip, the bigger the savings due to economies of scale available on bigger ships. Thus, increasing ship capacity from 300 to 3000 containers reduces per unit cost by 42% on the North Atlantic route and 55% on the Australian route. Figure 3.15 illustrates how economies of scale can bring about substantial savings.

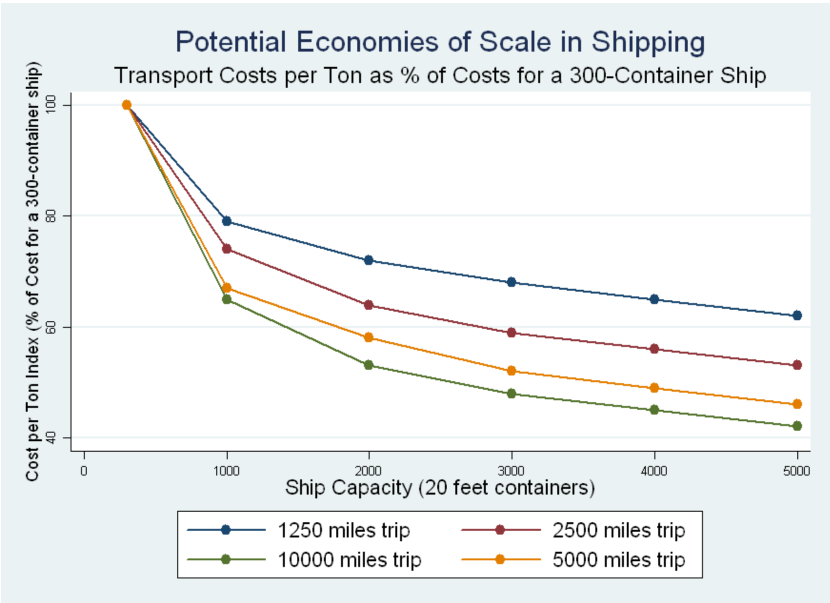

Figure 4.15: Economies of Scale in Container Shipping (reproduced from McKinsey Report)

Also, economies of scale can be achieved in ports since one container berth can replace up to 20 break-bulk berths due to productivity improvements. This means that only a few ports are needed to handle the entire container trade of the UK.

9. Hubs and Spokes

Very interesting industry dynamics came about after containerisation was introduced. Soon after containerisation spread, many shippers started realising that unbalanced trade meant that their ships would be carrying full containers on one leg of a journey only to return with empty boxes. This meant that the forwarder had to pay for both legs of the journey. This wiped out some of the savings introduced by the container. Slowly but steadily, some ports were developing into mega-ports that were handling not only domestic trade but also foreign trade. Shipping lines figured that if they could consolidate trade bound for adjacent countries, they could fill ships that would call at a mega-port and then dispatch the goods to their respective destinations by smaller ships or rail. This system has become known as the hub and spoke system in international shipping. This was a direct consequence of the economies of scale the containerisation allowed. In Northern Europe, for example, the port of Rotterdam has become a hub for Western European trade. Large oceangoing containerships call at Rotterdam with trade bound for Germany, the UK, France, and even Austria and Switzerland. Many such systems exist elsewhere such as Singapore and Hong Kong in Southeast Asia.

Thus an opportunity arose to minimise costs by either choosing one port of call supplied by feeders or more ports of call at either ends of the trans-oceanic voyage. McKinsey and Company (1972) calculates that a 500 mile round trip voyage by a 300-containers feeder ship costs £6300, whereas diverting a container ship 500 miles to pick up 300 extra containers would cost a 2000-containers ship £9,800, and a 1000-containers ship £5,600.

10. Offshoring and just-in-time manufacturing

    It is no secret the container allowed for raw materials to be shipped to distant countries to make use of their cheap labour to turn them into finished goods that are then sent by containers to markets. The frequency and reliability of the container service led the likes of Toyota and Honda to develop their just-in-time manufacturing. The result was lower inventories. This was clearly demonstrated in 2002, when a strike by the ILWU closed US Coast ports for 10 days. The shutdown of ports was almost immediately visible resulting in empty store shelves and idle assembly lines. Containerisation and just-in-time manufacturing is a topic for future research.

Based on the above, it should be understood that containerisation instigated a comprehensive transportation system that changed how shipping is conducted. The effects were felt not only in container trade but throughout the transportation industry. The implications of this is that the variable that we constructed measures/captures many aspects of the new technology that affected trade. The nature of the constructed containerisation measure that we use - the binary variable - means that there are limitations on the information necessary to separate between the different aspects of the new technology that we listed above. This is especially the case when we choose data points in the sample that are 5 years apart in part of the analysis.

What is perhaps worth mentioning (again) is that our container measure does not capture inland transport of containers by road. Containerisation became a compelling force in international trade that no country could avoid it. Being uncontainerised in port or rail does not mean that a country wasn't receiving containers. Not having a container port is clearly a disadvantage. We were surprised to find pictures on the internet that show containers being offloaded on the high sea onto smaller boats to get them to shore in the Comoros Islands which remained uncontainerised in the late 1980s (Figure 3.16). Our measure of containerisation does not capture this. The data that we present in this chapter does not cover cases such as the Comoros Islands.

Figure 4.16: Containerisation in the Comoros Islands (late 1980s)

4.6 Trade Data

The world trade flows data set used in this thesis is compiled by Feenstra et al. (2005) and is available from NBER. The data set is constructed from United Nations trade data. The data set covers the period 1962-2000. The set of countries covered in the data set is not uniform across the entire period however. The period 1962-1983 covers most if not all of the world countries and territories. For the period 1984-2000, the data set covers trade of 72 countries only. This means that only bilateral trade flows of the 72 countries with the rest of the world and among each other are included. Here too, the panel data set is unbalanced. Since we are interested with the period 1962-1990, the number of countries for which is data is available becomes 63. The list of the 63 countries is provided in the appendix (table A.5). The panel data set is unbalanced and some observations are missing. We have confirmed with the authors that these observations are missing. It is therefore not known whether the missing observations are positive trade flows or zeros, although the authors stressed that it is safer to assume that observations are missing rather than zero.

The advantage of this data set is that it is the most comprehensive bilateral trade flows data set out there for our purposes. Feenstra et al. depend mainly on importer data in compiling the data set but use exporter data where importer data is missing. Also many corrections and additions are made to the UN data. Another advantage of this data set is that it has a product dimension as well. The data set makes available trade flows at the 4-digit SITC Rev 2. This will be key to our study as will become clear later in this thesis.

The data set reports trade as small as 1000 USD for the period 1962-1983 and the minimum trade value reported is 100,000 USD between 1984-2000 (only a few observations with values less than 100,000 USD). With regards to the country aggregate trade data, when asked whether it was safe to assume the missing observations are all zero trade values, the authors confirmed that this was not a good assumption. They confirmed that it would be safer to assume that the data is missing and non-zero rather than zero. One of the authors gives the following example. It was noticed that the data indicated that there was no trade (no data/missing) between the United States and Mexico for a number of years (either from the UN data or the Stats Canada data).

This could not have been the case of course. They had to revert to the U.S. trade data to supplement that missing part. In addition, the authors confirmed that missing trade could be because the value of the trade was very low. For many countries, trade values of less than 100,000 were missing.

From this data set, we choose a sample period between 1962-1990. Containerisation as an international phenomenon started in 1966 with the first Sea-Land ship crossing the Atlantic between New York and Europe. The last countries to containerise in our data set were Bermuda, Ethiopia, Guinea, Malta, and Myanmar in 1983. Since containerisation started internationally in 1966, our chosen period thus includes 4 years of pre-containerisation period for the first containerisers and 7 years of post-containerisation for the latest entrants. This should allow sufficient time for adjustment to containerisation.

We choose to include years up to 1990 since the fall of the Berlin Wall caused the political map to be redrawn. Many countries disappeared and others emerged. The Soviet Union collapsed giving rise to 15 new countries. Also, Germany was reunified. The 1990s was a decade in which Europe's map was redrawn. In 1993, Czechoslovakia split to form the Czech Republic and Slovakia. Yugoslavia started disintegrating from 1991 and was eventually broken up into 6 independent republics (not to count Kosovo). The geographic and political changes that took place in the 1990s makes it difficult to conduct a controlled study of containerisation beyond 1990. Another reason why we use data up to 1990 is that air freight was still expensive around this time and very limited trade, mainly high value goods in the most developed countries, were being flown in or out (see Hummels (2007). This allows for a controlled environment to study containerisation.

4.7 Bilateral Trade Data: Descriptives and Graphs

We start exploring our data by plotting world trade between 1962 and 1990 based on bilateral trade flows from the data set described above. In figure 3.17, we plot nominal total trade. Between 1962 and 1990, world trade increases from 130 billion USD in 1962 to 3.47 trillion USD in 1990, an increase of around 26-fold. In figure 2.1, we showed world trade deflated by US GDP deflator. In real terms, world trade increases more than 6-fold between 1962 and 1990 from around 500 billion USD to 3.47 trillion (1990

USD).

Figure 4.17: World Trade 1962-1990 non-deflated

Recall that 119 countries port-containerise between 1966 and 1983. In our trade data set, we have an additional 18 non-landlocked countries that are non port/rail-containerised in the period 1962-1990. In addition, we have a total of 21 countries that are landlocked and thus naturally non port-containerised. Refer to the appendix for a list of these countries (table A.4) . This gives us a sample of 157 countries. This means that we have 157*156 or 24,492 potential aggregate bilateral trade relationships per year.

In figure 3.18, we plot the value of the individual trade observations in our data set between the years 1962-1990. This shows us the dispersion of values per year. The plot indicates significant increase in dispersion over the years. In the 1960s and early 1970s, most of the observations are clustered at the bottom. This changes in the late 1970s and the 1980s where individual observations larger than $1 billion in value are not infrequent.

The percentage of missing observations at the country-pair level is around 68% of

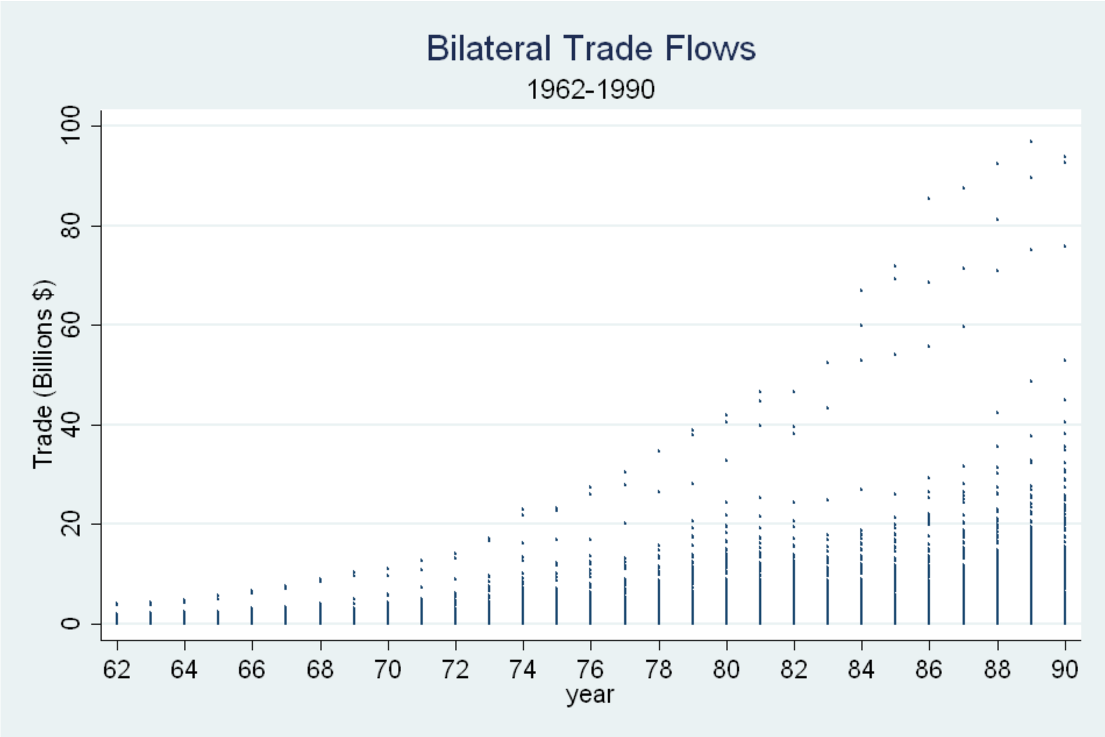

Figure 4.18: Plotting individual bilateral trade flows

total potential observations in 1962, around 50% in the mid 1970s, and again around two-third in the late 1980's. We know the reason for the increase of missing observations in the late 1980's is because of data set coverage described above. Of all non-missing observations, 33% have a trade value of less than $100,000 in 1962, and 42% have a value of more than $1 million. Only 12 observations for that year are $1 billion or higher. In 1983, only 21% of the observations are $100,000 or lower. But 73% of all observations are now higher than $1 million and 300 trade relations are higher than 1 billion USD.

In Figure 3.19, we plot total world trade (exports and imports) as well as total trade of containerised countries. We make a distinction between observations in which only one of the partner countries is containerised and those in which both countries are port-containerised. Total trade of containerised countries where both countries are port-containerised account for almost all of international trade. Also total trade where only one country is containerised is highly correlated with total international trade. This plot seems to support the claim that containerisation played a role in encouraging globalisation in the period after the 1960s.

Figure 3.20 plots trade series by decade of containerisation, i.e. trade of countries that containerised in 1960s versus those that containerised in the 1970s and 1980s. Here too we consider port containerisation only. Trade of countries that containerised in the 1960s - and there are only 17 of them - accounts for most of international trade. This is followed by countries who containerised in the 1970s, and these form the bulk of our sample. Surprisingly, countries that containerised in the 1980s did not increase their trade between 1980 and 1990.

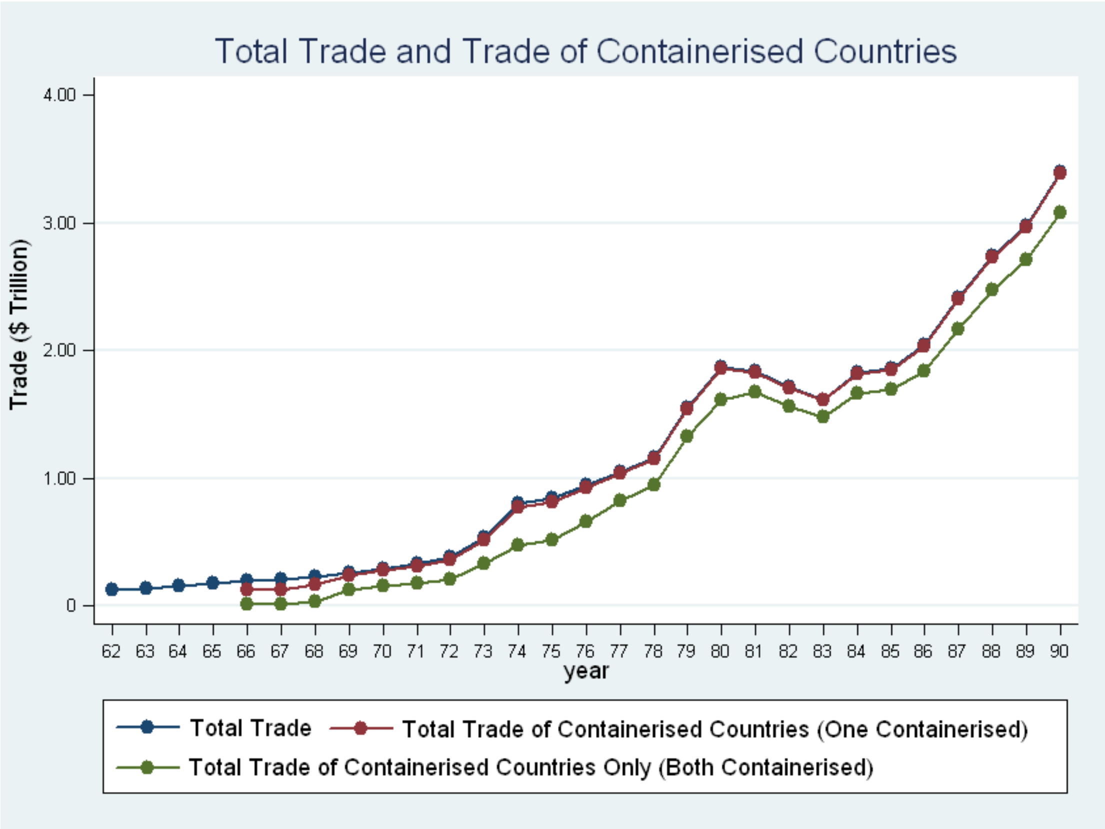

Figure 4.19: Plot of Total Trade against Containerised Countries' Total Trade

The data set described above provides bilateral trade flows at the 4-digit SITC Rev 2 product classification. Between 1962 and 1990, there are 19,519,708 positive trade flows. At the 4-digit SITC classification, there are 1058 product categories. The 4-digit trade flows will be used to investigate the effects of containerisation at the product level in chapters 6 and 7.

4.8 Containerisability of Products

Not all products can be moved in containers. In modern shipping, there are two types of cargo: Bulk and Containerised cargo. 'Bulk' in shipping refers to cargoes that are

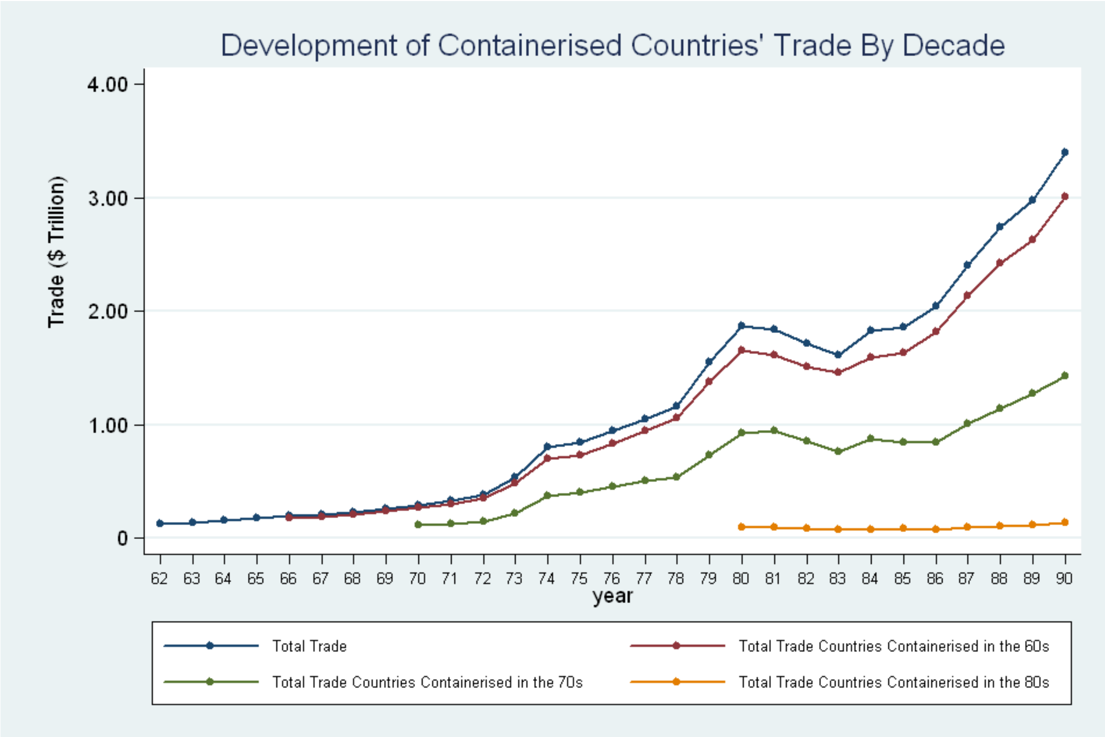

Figure 4.20: Plot of Containerised Countries' Trade by Decade

shipped in complete shiploads. Before the container, the trade that did not move as bulk was known as general cargo. To move as bulk, the trade should be big enough to make it feasible to transport in entire shiploads rather than as 'general cargo'. This is generally the case for oil, grain, coal, ores, fertilisers, etc. Other products have to be moved in bulk because they are unsuitable for containerisation owing to their nature. One could think of live animals, explosives, precious metals and stones, etc. Also, maritime transport literature classifies heavy machinery as unsuitable for the container, which is intuitive due to size and weight constrictions.

Stopford (2009) lists four main categories of bulk cargo:

- Liquid bulk: transported in tankers such as oil, oil products, liquid chemicals, vegetable oils, and wine.
- The *five major bulks*: iron ore, grain, coal, phosphates and bauxite. These are transported in shiploads in the holds of ships.
- Minor bulks: This category covers many other commodities that travel in shiploads. Most important are steel products, cement, gypsum, non-ferrous metal ores, sugar, salt, sulphur, forest products, wood chips and chemicals.

- Specialist bulk cargoes: Motor vehicles, steel products, refrigerated cargo, and abnormally large structures such as offshore installations.

Containerisation International Yearbook (1971, pages 70-71) defines bulk cargo as 'cargo defined by its kind and weight or volume only, and conveyed loose in separate, reserved wagons, vehicles, or ship's hold sections'. From the above, it is clear that not all products are moved or can be moved in containers. In the next section, we explore further the containerisability of goods traded.

4.8.1 Containerisability of Products at the 4-digit SITC Disaggregate Product Level

Containerisation International Yearbook (1971) classifies goods at the SITC product level into three grades: suitable for containers - Class A, goods of limited suitability for containers - Class B, and goods not suitable for containers - Class C. The classification is based on the German Engineers' Society analysis from 1968. The classification looks at the physical properties of goods entirely. The good is classified as suitable for the container if its nature allows it to be transported in containers without being damaged. For instance, wheat cannot be containerised because it locks humidity easily and hence it is transported in specially equipped ships. Some other products cannot be containerised because their size won't allow it. One can think of cars, large installations, etc.

This classification is based on a 1968 study. In this study, the products that are classified as suitable for containerisation were readily transportable in containers without any adjustment. Unfortunately, this is the only classification available to us.

One caveat of this classification is that products that are classified as unsuitable for containerisation might become containerisable later on as containerisation caught on. One can think of perishable foods. These became containerisable as refrigerated containers were introduced. Some products were only sometimes suitable for containerisation or were strongly affected by containerisation because their intermediate inputs were containerisable (such as cars). On the other hand, some products are not and will never be moved in containers such as oil or gas. Ideally, one would like to have a classification that is updated as more products become containerisable. This information does not exist as far as we are aware.

Another disadvantage is that this classification does not take into account the volume of trade. The volume of trade (shipment) is a determining factor in deciding whether a shipment is to be transported in bulk or in container. However, in order to take the volume of trade into consideration, one requires individual shipment data. It is therefore possible to classify products according to their containerisability by considering their physical properties only.

This classification of containerisation that we use has the advantage that it is based on a classification made at the start of the period of containerisation. This makes our analysis less prone to endogeneity (simultaneity bias) when we restrict our sample to those products that were classified as containerisable in 1968. Other products may have been adjusted to be transported in containers because of their trade volumes and can thus benefit from containerisation. This could introduce an element of endogeneity into the analysis because the products classified as 'not suitable' or 'of limited suitability' include endogenous components.

Under the 1968 classification, we are able to place goods in one of the 3 categories of containerisability at the 4-digit SITC level. The product containerisability classifications are listed in the appendix (tables A.7-A.9). In these tables, we sometimes list products at the 1-, 2-, or 3-digits level for convenience. For instance, all products at the 4-digit level under the 1-digit industry 3 (Mineral fuels, lubricants and related materials) were classified as not suitable for containerisation, we just list industry 3 as not suitable for containerisation in the table.

Moving forwards, for convenience, we call 'containerisable' trade that trade in products that are classified as suitable for containers in 1968. 'Non-containerisable' trade refers to trade that is classified as of limited suitability or not suitable for containers although the term 'non-containerisable' might be misleading for reasons discussed above.

4.8.2 Containerisability at the 1-digit SITC Product Level

At the 1-digit industry level, we have 10 product categories. In order to classify whether an industry is containerisable or not at the 1-digit level, one can count the number of sub-products that are suitable for containers and those that are non-containerisable and then classify an industry as containerisable if the number of products suitable for containers exceeds the number of non-containerisable products.

Table 4.1: Shares of Containerisable Trade in Total Trade at the 1-digit industry level - USA 1962

SITC	Description	Containerisability	% Containerisability
0	Food and Live Animals	Non-Containerisable	46%
1	Beverages and tobacco	Containerisable	100%
2	Crude materials, inedible, except fuels	Containerisable	56%
3	Mineral fuels, lubricants and related materials	Non-Containerisable	0%
4	Animal and vegetable oils, fats and waxes	Containerisable	100%
5	Chemicals and related products, n.e.s.	Containerisable	59%
6	Manufactured goods classified chiefly by material	Containerisable	95%
7	Machinery and transport equipment	Containerisable	60%
8	Miscellaneous manufactured articles	Containerisable	100%
9	Commodities and transactions not elsewhere classified	Non-Containerisable	0%

It is however more appropriate to give products different weights within the 1-digit industry. To do so, we choose the US as the reference country since containerisation started in the US and we choose 1962 as the year of reference (before containerisation entered international trade). In practice, we sum up trade volumes (both imports and exports) of the US in 1962 based on the containerisability of the products under each 1-digit industry. We then calculate the percentage or share of containerisable trade in total trade in the 1-digit industry. Doing this results in the percentages/shares presented in table 4.1.

Based on this simple calculation, we identify 3 industries that are 100% containerisable. These are industries 1, 4, and 8, or Beverages and tobacco, Animal and vegetable oils, fats and waxes, and Miscellaneous manufactured articles. Industry 6 (Manufactured goods classified chiefly by material) is almost fully containerisable (95%). Two industries that are fully non-containerisable are industries 3 (Mineral fuels, lubricants and related materials) and 9 (Commodities and transactions not elsewhere classified). The remaining industries range in their containerisability between 40% and 60%.

Based on this classification, we consider a 1-digit industry containerisable if it has a weight of 50% or higher and non-containerisable if it has a weight of less than 50%. This means that we have 7 industries that are considered containerisable and 3 industries are classified as non-containerisable[11].

4.9 Containerisability and Trade : Descriptives

Based on our containerisability classification of products at the 4-digit product level as discussed above, we plot some relationships and graphs to explore the evolution of products or commodity trade.

[11] We test the robustness of the empirical results to the choice of the 50% threshold in chapter 6 where we use this classification and the results are robust to the 40% and 60% thresholds.

In figure 3.21, we plot world containerisable and non-containerisable trade between 1962 and 1990, deflated by US GDP deflator and based on the trade data described above. We notice that the two trade series are very close to each other and move together until 1983 where containerisable trade becomes higher than non-containerisable trade. Removing fuels from non-containerisable trade (figure 3.22), containerisable trade becomes strictly higher than non-containerisable trade for the entire period.

When we plot the ratio of containerisable to non-containerisable trade, we see that this ratio is around 1.3 in 1962 and is slowly downward sloping to 1.2 in 1973, then drops sharply below 1 in 1974 due to the oil crisis and the rise in oil prices, then rises again above 1 in 1978 to drop back below 1 in 1979 in the wake of the second oil crisis to remain below 1 until 1983. Between 1983 and 1990, there is a clear increase in the ratio. Looking at the plot in figure 3.23, we can conclude that this sharp increase is mainly due to containerisable trade increasing at a higher rate than non-containerisable trade after 1983. This could indicate a transition in the composition of trade in the wake of containerisation. Also, interestingly, the early 1980s is the period when just-in-time manufacturing was introduced and started gaining ground. Also, in that period, computer were being employed more frequently in the logistics of shipping[12].

In figures 3.22 and 3.24, we replicate the plots in 3.21 and 3.23 respectively while excluding fuels. Without fuels, the spikes and troughs in non-containerisable trade due to the volatile oil prices are not evident in figure 3.22. There is a slight concave shape in non-containerisable trade between 1974 and 1980, perhaps due to increase in real prices of some commodities due to the increase in oil prices. Non-containerisable trade recovers to its previous trend after 1983. Figure 3.24 suggests that the ratio of containerisable trade to non-containerisable trade minus fuels is stable, around 1.6 between 1962 and 1983. This ratio increases after 1983 to reach a value of 2 in 1987.

After plotting the trends and behaviour of the two trade series that result from classifying products according to their containerisability, we would like to understand what was being traded and how the composition of trade fares in the period of containerisation. To do so, we list the top twenty containerisable and non-containerisable products at the 4-digit SITC disaggregate product level before containerisation started

[12]The phenomenon of just-in-time manufacturing and its relationship to containerisation deserves more researching on its own but this is not researched in this thesis. It will be the subject of future research.

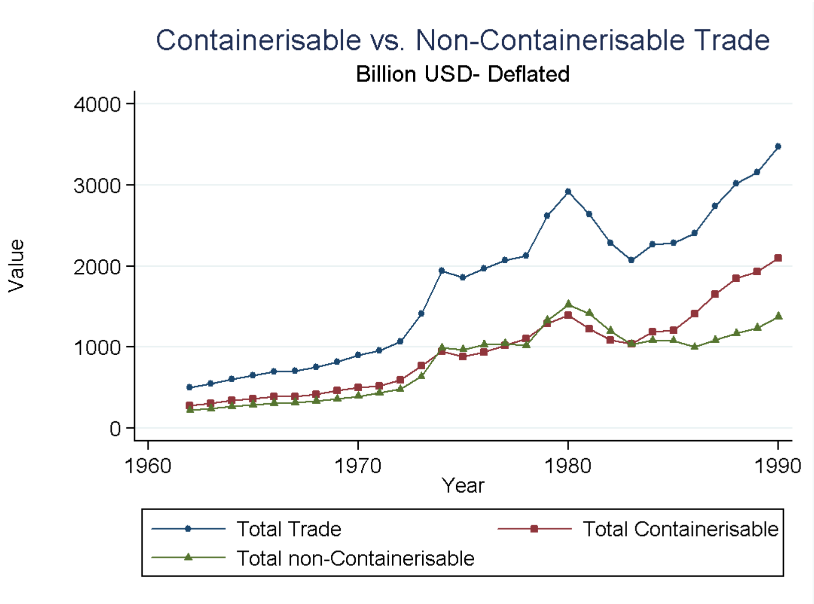

Figure 4.21: Development of Containerisable vs. Non-Containerisable Trade

in 1962 and after containerisation was largely completed in 1990. Comparing tables 4.2 and 4.3, the top 20 traded non-containerisable products in 1962 and 1990 include basic commodities such as oil and its derivatives, wheat, iron, and coal. They also include manufactures that are large in size such as passenger cars, ships and aircraft. The difference between 1962 and 1990 is that manufactures gain prominence in the rankings in 1990 (aircraft and transport vehicles) compared to 1962 where basic commodities are relatively higher in ranking.

In tables 4.4 and 4.5, we list the top 20 containerisable products in 1962 and 1990 respectively. Unlike tables 4.2 and 4.3, the differences between these two lists are striking. In 1962, the top 20 containerisables list is dominated by containerisable commodities such as coffee, cotton, copper, natural rubber, wool, sugars and tea. Only a few manufactures feature in the list and these include telecommunications equipment, machine tools for working metals and internal combustion engines. On the other hand, in 1990, the top 20 containerisables list features exclusively manufactures and most of them are high-tech manufactures such as microcircuits, computers and consumer electronics. Also, it is interesting that many of products listed as containerisables in 1990 include parts and accessories of non-containerisables such as cars and aircraft. It is argued that containerisation allowed for this trade and the fragmentation of the production process. These two tables suggest that the composition of trade changed after containerisation

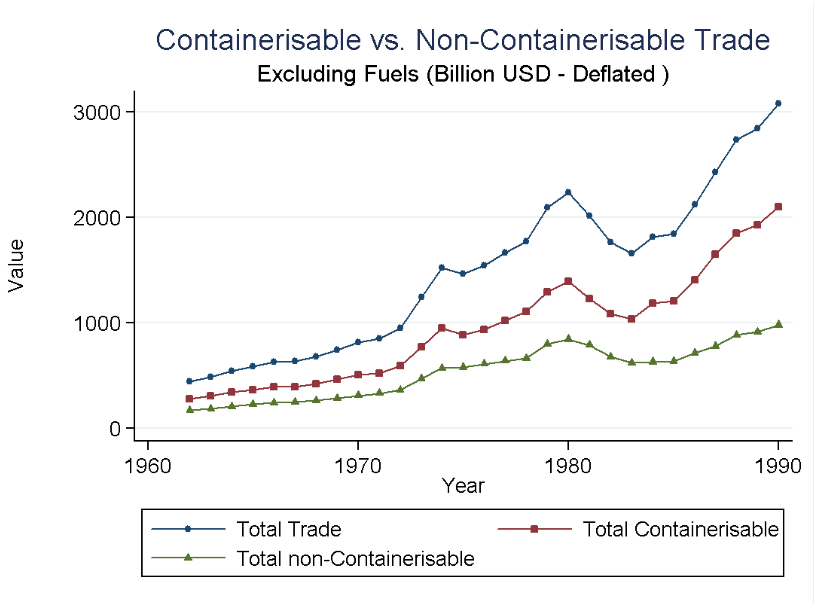

Figure 4.22: Development of Containerisable vs. Non-Containerisable Trade excluding Fuels

and there is a clear move towards trade that is dominated by manufactures and parts.

Table 4.2: Top 20 non-containerisable products by value in 1962

Rank	SITC code	Description
1	3330	Petrol.oils & crude oils obtained from bituminous minerals
2	7810	Passenger motor cars, for transport of pass.& goods
3	0410	Wheat (including spelt) and meslin, unmilled
4	9310	Special transactions & commod., not class.to kind
5	2810	Iron ore and concentrates
6	3344	Fuel oils, n.e.s.
7	2482	Wood of coniferous species, sawn, planed, tongued etc
8	3220	Coal, lignite and peat
9	7932	Ships, boats and other vessels
10	7928	Aircraft, n.e.s.balloons, gliders etc and equipment
11	7920	Aircraft & associated equipment and parts
12	7200	Machinery specialized for particular industries
13	0440	Maize (corn), unmilled
14	3343	Gas oils
15	3341	Motor spirit and other light oils
16	0111	Meat of bovine animals, fresh, chilled or frozen
17	7220	Tractors fitted or not with power take-offs, etc.
18	7821	Motor vehicles for transport of goods/materials
19	3340	Petroleum products, refined
20	3345	Lubricating petroleum oils & other heavy petrol.oils

After listing the top 20 traded containerisable and non-containerisable products, we plot the trade series for the top 5 traded products from the lists in figures 3.25 to 3.28.

In figure 3.25, the top 5 containerisable products in 1962 are all basic (industrial) commodities. In 1990 (figure 3.26), this is completely different. Four out of the five top containerisable products are manufactured parts or finished products. It is interesting here that except for diamonds, the other 4 products were not traded before 1975. It has been suggested that containerisation allowed for the trade in parts/intermediates and the creation of new trade. This figure gives the impression that just after containerisation

Table 4.3: Top 20 non-containerisable products by value in 1990

Rank	SITC code	Description
1	3330	Petrol.oils & crude oils obtained from bituminous minerals
2	7810	Passenger motor cars, for transport of pass.& goods
3	9000	Commodities and transactions not elsewhere classified
4	3341	Motor spirit and other light oils
5	7924	Aircraft exceeding an unladen weight of 15000 kg
6	9310	Special transactions & commod., not class.to kind
7	7821	Motor vehicles for transport of goods/materials
8	3344	Fuel oils, n.e.s.
9	7932	Ships, boats and other vessels
10	3343	Gas oils
11	3222	Other coal, whether/not pulverized, not agglomerated
12	3413	Petroleum gases and other gaseous hydrocarbons
13	2482	Wood of coniferous species, sawn, planed, tongued etc
14	0111	Meat of bovine animals, fresh, chilled or frozen
15	3414	Petroleum gases and other gaseous hydrocarbons nes
16	0360	Crustaceans and molluscs, fresh, chilled, frozen etc.
17	0412	Other wheat (including spelt) and meslin, unmilled
18	6727	Iron or steel coils for re-rolling
19	3342	Kerosene and other medium oils
20	3345	Lubricating petroleum oils & other heavy petrol.oils

Table 4.4: Top 20 containerisable products traded by value in 1962

Rank	SITC code	Descr
1	0711	Coffee, whether or not roasted or freed of caffeine
2	2631	Cotton (other than linters), not carded or combed
3	7842	Bodies for the motor vehicles of 722/781/782/783
4	6821	Copper and copper alloys, refined or not, unwrought
5	2320	Natural rubber latex; nat.rubber & sim.nat.gums
6	2681	Seep's or lambs' wool, greasy or fleece-washed
7	7640	Telecommunications equipment and parts
8	6522	Cotton fabrics, woven, bleach.mercerized dyed, printed
9	7360	Mach.tools for working metal or met.carb., parts
10	6411	Newsprint
11	7244	Mach.for extruding man-made textiles and parts
12	1210	Tobacco, unmanufactured; tobacco refuse
13	0611	Sugars, beet and cane, raw, solid
14	7130	Internal combustion piston engines & parts
15	7000	Machinery and transport equipment
16	7499	Other non-electric parts & accessories of mach.
17	6530	Fabrics, woven, of man-made fibres
18	7230	Civil engineering & contractors plant and parts
19	7430	Pumps & compressors, fans & blowers, centrifuges
20	6746	Sheets & plates, rolled; thickness of less than 3mm.

Table 4.5: Top 20 containerisable products traded by value in 1990

Rank	SITC code	Description
1	7849	Other parts & accessories of motor vehicles
2	7764	Electronic microcircuits
3	7599	Parts of and accessories suitable for 751.2, 752- (Calculating machines/Automatic data processing machines)
4	7284	Mach.& appliances for specialized particular ind.
5	6672	Diamonds, unwork.cut/otherwise work.not mounted/set
6	8510	Footwear
7	7721	Elect.app.such as switches, relays, fuses, plugs etc.
8	7649	Parts of apparatus of division 76— (Telecommunications, sound recording apparatus)
9	5417	Medicaments (including veterinary medicaments)
10	7523	Complete digital central processing units
11	8939	Miscellaneous art.of materials of div.58
12	8942	Children s toys, indoor games, etc.
13	7525	Peripheral units, including control & adapting units
14	7929	Parts of heading 792– (Aircraft), excl.tyres, engines
15	7788	Other elect.machinery and equipment
16	5989	Chemical products and preparations, n.e.s.
17	8219	Other furniture and parts
18	8983	Gramophone records and sim.sound recordings
19	7611	Television receivers, colour
20	7524	Digital central storage units, separately consigned

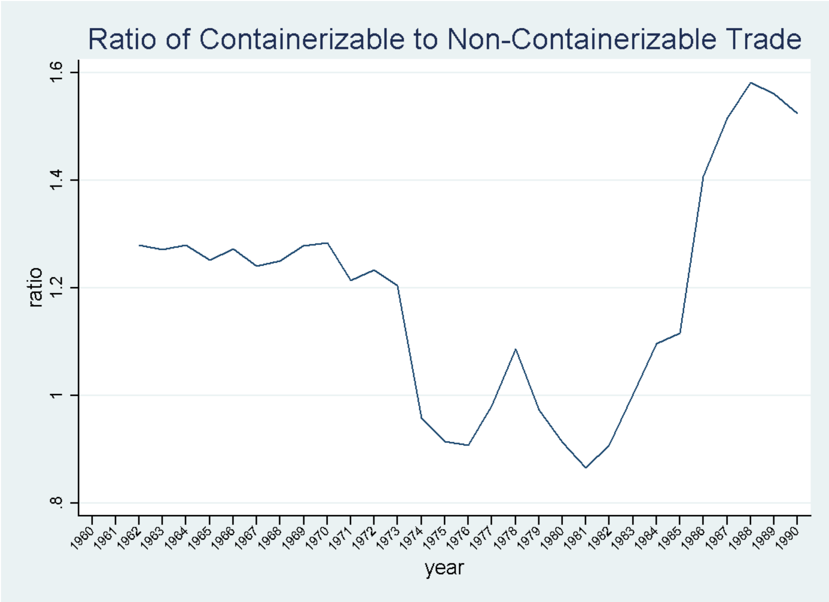

Figure 4.23: Ratio of Containerisable to Non-Containerisable Trade

started, products that were not traded previously now dominate world trade. How much containerisation contributed to the creation of new trade is subject to future research.

In figures 3.27 and 3.28, oil dominates non-containerisable trade in 1962 and 1990. Other highly traded products include heavy manufactures that are not containerisable but whose manufacture and trade might have been aided by the containerisability of their parts such as cars and aircraft.

4.9.1 What are North South Trading Before and After Containerisation?

We define North countries as OECD countries minus Turkey[13]. Of the four new aspects of modern world trade highlighted by Krugman (1995), the creation of production chains or the breaking of the production process into many geographically separated steps and the emergence of large exports of manufactured goods from low-wage to high-wage nations are perhaps the most affected and enabled by containerisation. We explore these trends and aspects in our data set. We do so by restricting the trade flows at the 4-digit SITC product disaggregate level to North-South trade in containerisable products.

[13]While Turkey is a founding member of the OECD, Turkey is a late containeriser. Twenty two countries are classified as North in our sample. These are: Australia, Austria, Belgium, Canada, Denmark, Finland, Fm German FR, France, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and USA

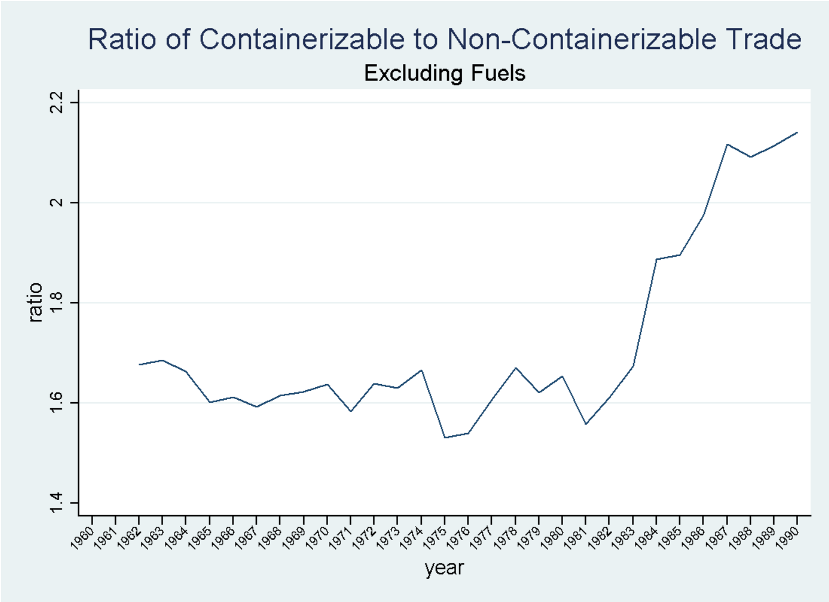

Figure 4.24: Ratio of Containerisable to Non-Containerisable Trade

Table 4.6: Top 20 North-South containerisable products traded by value in 1962

Rank	SITC code	Description
1	0711	Coffee, whether or not roasted or freed of caffeine
2	2631	Cotton (other than linters), not carded or combed
3	6821	Copper and copper alloys, refined or not, unwrought
4	0611	Sugars, beet and cane, raw, solid
5	2320	Natural rubber latex; nat.rubber & sim.nat.gums
6	7842	Bodies for the motor vehicles of 722/781/782/783 (tractors/cars/trucks/busses)
7	6522	Cotton fabrics, woven, bleach.mercerized dyed, printed
8	0741	Tea
9	1210	Tobacco, unmanufactured; tobacco refuse
10	0721	Cocoa beans, whole or broken, raw or roasted
11	7244	Mach.for extruding man-made textiles and parts
12	2681	Seep's or lambs' wool, greasy or fleece-washed
13	7130	Internal combustion piston engines & parts
14	7230	Civil engineering & contractors plant and parts
15	7499	Other non-electric parts & accessories of mach.
16	1121	Wine of fresh grapes (including grape must)
17	0813	Oil-cake & other residues (except dregs)
18	5417	Medicaments (including veterinary medicaments)
19	0460	Meal and flour of wheat and flour of meslin
20	6530	Fabrics, woven, of man-made fibres

In tables 4.6, we list the top 20 containerisable traded products in North-South trade before containerisation (1962) and after containerisation (1990). What we find is that in 1962, the top 20 containerisable products traded between South and North countries are dominated by basic commodities. The top 5 commodities traded are all basic commodities: coffee, cotton, copper, sugars, and natural rubber. Fast forward to 1990 and only 3 of the top 20 traded containerisable products in North-South trade are basic commodities (table 4.7). The remaining 17 products are all manufactured products and many of them are hi-tech or parts of non-containerisable finished products. It is clear that the composition of trade has changed radically in the 28-year period.

Is it true that South countries have become suppliers to North countries of products

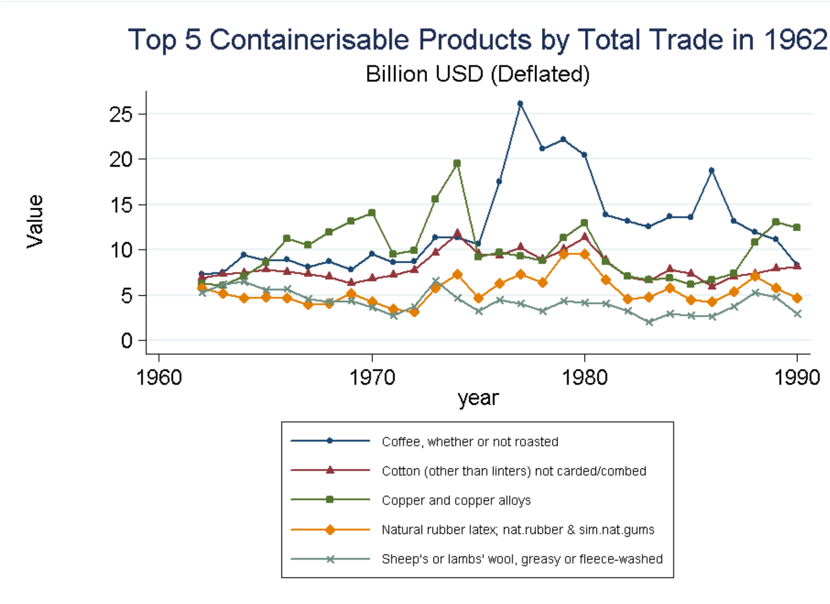

Figure 4.25: Trade in Top Containerisable Products(1962)

Table 4.7: Top 20 North-South containerisable products traded by value in 1990

Rank	SITC code	Description
1	7764	Electronic microcircuits
2	6672	Diamonds, unwork.cut/otherwise work.not mounted/set
3	8510	Footwear
4	7849	Other parts & accessories of motor vehicles
5	7284	Mach.& appliances for specialized particular ind.
6	7649	Parts of apparatus of division 76— (Telecommunications, sound recording apparatus)
7	7599	Parts of and accessories suitable for 751.2-, 752– (Calculating machines/Automatic data processing machines)
8	8942	Children s toys, indoor games, etc.
9	7721	Elect.app.such as switches, relays, fuses, plugs etc.
10	8439	Other outer garments of textile fabrics
11	8451	Jerseys, pull-overs, twinsets, cardigans, knitted
12	6821	Copper and copper alloys, refined or not, unwrought
13	0711	Coffee, whether or not roasted or freed of caffeine
14	7788	Other elect.machinery and equipment
15	7525	Peripheral units, including control & adapting units
16	7929	Parts of heading 792– (Aircraft), excl.tyres, engines
17	7611	Television receivers, colour
18	7731	Insulated, elect.wire, cable, bars, strip and the like
19	7524	Digital central storage units, separately consigned
20	5989	Chemical products and preparations, n.e.s.

other than the traditional basic commodities? To answer this question, we restrict our data sets to exports from South countries and North countries and explore any patterns there.

In tables 4.8 and 4.9, we list the top 20 containerisable exported products from South to North countries before containerisation (1962) and after containerisation (1990). What we find is that all except one of the top 20 containerisable exports from South to North countries before containerisation are basic commodities. This confirms that South countries were mainly suppliers of basic commodities for the manufacturing sectors of North countries before containerisation. After containerisation in 1990, the change is striking. South countries no longer only supply basic commodities. South countries

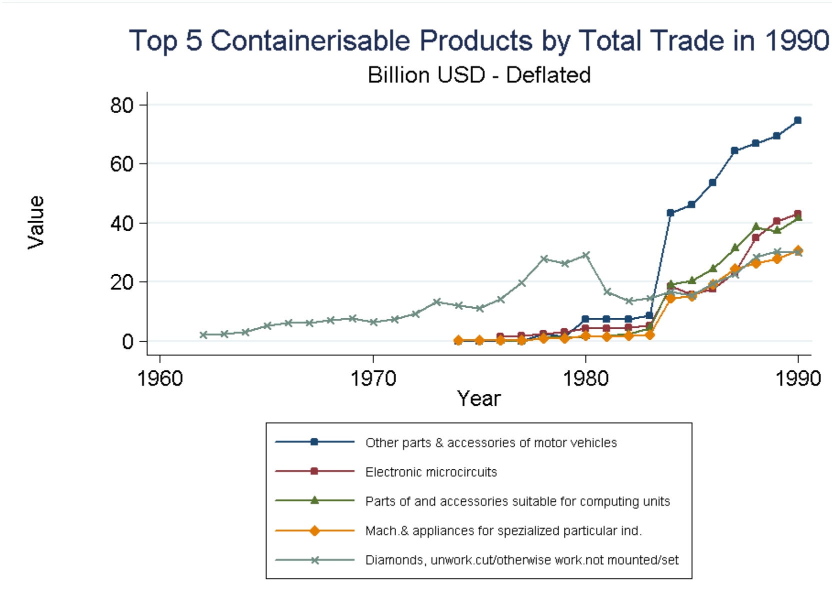

Figure 4.26: Trade in Top Containerisable Products(1962)

have also become suppliers of manufactures - basic and hi-tech. The top exported containerisable product is footwear and the second is electronic microcircuits. Of the top 20 exported products by South countries, only 4 are basic commodities in 1990.

This evidence supports the claim that the new patterns in trade especially the fragmentation of the production process and the emergence of manufacturing power houses in South countries might have been enabled by containerisation. We investigate the effects of containerisation on North-South trade in ensuing chapters.

Table 4.8: Top 20 containerisable exports from South to North by value in 1962

Rank	SITC code	Description
1	0711	Coffee, whether or not roasted or freed of caffeine
2	2631	Cotton (other than linters), not carded or combed
3	6821	Copper and copper alloys, refined or not, unwrought
4	2320	Natural rubber latex; nat.rubber & sim.nat.gums
5	0611	Sugars, beet and cane, raw, solid
6	0741	Tea
7	0721	Cocoa beans, whole or broken, raw or roasted
8	1210	Tobacco, unmanufactured; tobacco refuse
9	2681	Seep's or lambs' wool, greasy or fleece-washed
10	0813	Oil-cake & other residues (except dregs)
11	1121	Wine of fresh grapes (including grape must)
12	6871	Tin and tin alloys, unwrought
13	2221	Groundnuts (peanuts), green, whether or not shelled
14	6545	Fabrics, woven, of jute or of other textile bast fibre
15	2231	Copra
16	2640	Jute & other textile bast fibres, nes, raw/processed
17	2120	Furskins, raw (including astrakhan, caracul, etc.)
18	8420	Outer garments, men's, of textile fabrics
19	0814	Flours & meals, of meat/fish, unfit for human food
20	2654	Sisal & other fibres of agave family, raw or proce.

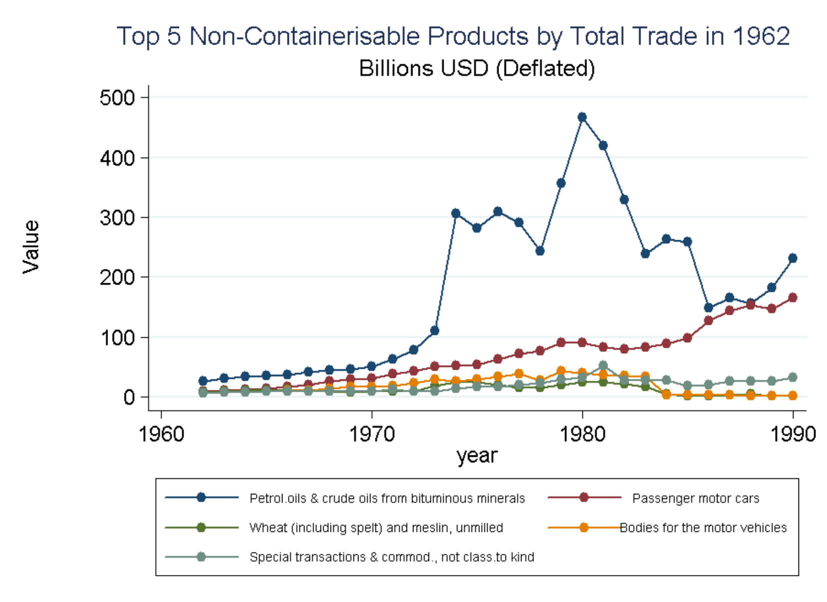

Figure 4.27: Trade in Top Non-Containerisable Products(1962)

Table 4.9: Top 20 containerisable exports from South to North by value in 1990

Rank	SITC code	Description
1	8510	Footwear
2	7764	Electronic microcircuits
3	6672	Diamonds, unwork.cut/otherwise work.not mounted/set
4	8942	Children s toys, indoor games, etc.
5	8439	Other outer garments of textile fabrics
6	8451	Jerseys, pull-overs, twinsets, cardigans, knitted
7	0711	Coffee, whether or not roasted or freed of caffeine
8	6821	Copper and copper alloys, refined or not, unwrought
9	7599	Parts of and accessories suitable for 751.2-, 752–
10	8310	Travel goods, handbags, brief-cases, purses, sheaths
11	7524	Digital central storage units, separately consigned
12	8423	Trousers, breeches etc.of textile fabrics
13	8481	Art.of apparel & clothing accessories, of leather
14	8459	Other outer garments & clothing, knitted
15	8441	Shirts, men's, of textile fabrics
16	7525	Peripheral units, including control & adapting units
17	7611	Television receivers, colour
18	8435	Blouses of textile fabrics
19	8462	Under garments, knitted of cotton
20	6841	Aluminium and aluminium alloys, unwrought

4.10 Other Relevant Data

GDP per capita data are obtained from the Penn World Tables (version 6.3)[14]. The Penn World Tables are missing GDP data for the period 1962-1970 for some countries. We fill in the gaps where available from the World Development Indicators of the World Bank [15]. GDP figures are at current prices adjusted for PPP. After consolidating the GDP data with the trade flows and the information about containerisation data, we end up with 127 countries in our sample. A list of these countries is presented in the appendix (table A.6).

[14]Source: http://pwt.econ.upenn.edu/

[15]These countries are: Afghanistan, Bahamas, Belize, Bermuda, Cambodia, Kuwait, Oman, St. Kitts and Nevis, Sudan, Suriname.

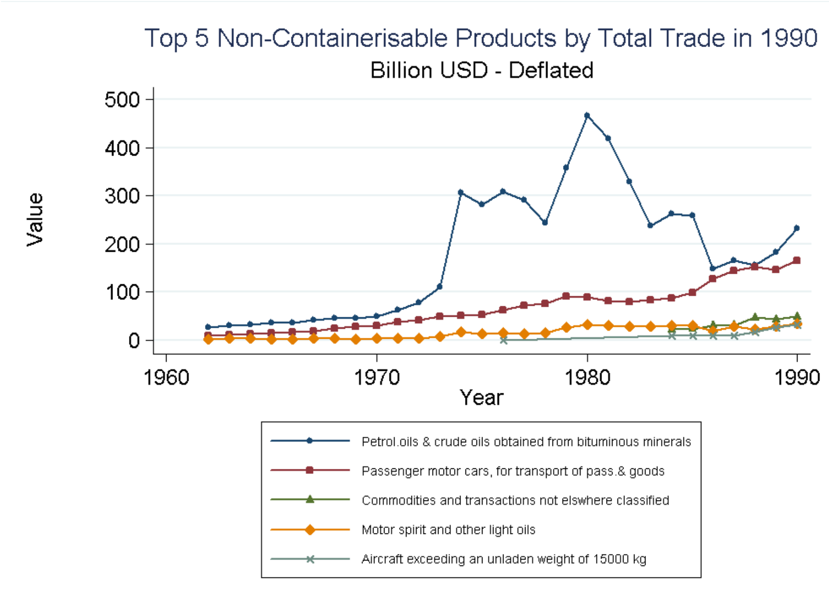

Figure 4.28: Trade in Top Non-Containerisable Products(1990)

Main gravity variables (distance, language, border, etc) are all taken from CEPII and have been compiled and used by Head et al. (2010) [16]. In the ensuing chapters, our empirical specifications allow for a comparison of the effects of the container variable with the policy variables FTAs, GATT membership, and common currency.

The three policy variables are also taken from CEPII but we mention their sources here. FTAs are taken from table 3 of Baier and Bergstrand (2007) supplemented with the WTO web site and qualitative information contained in Frankel (1997).

GATT membership of different countries over time comes from the WTO web site. The data on currency unions are an updated and extended version of the list provided by Glick and Rose (2002).

[16]Source: http://www.cepii.fr

Chapter 5

Econometric Estimation of the Effects of Containerisation on International Trade Flows at the Country Level

5.1 Introduction

This thesis attempts to measure the extent to which containerisation contributed to the rise in international trade. In this chapter, we move to investigate empirically the effects that containerisation has had on international trade flows. Using trade data and the container measure constructed in the previous chapter, we attempt various empirical specifications to try to pin down the right specification in order to identify the effects of containerisation. The dimension of the investigation in this chapter is the bilateral country aggregate trade flows.

In order to answer the question as to what the effects of containerisation were on international trade, we try to separate the effects of containerisation from other determinants of trade. Some of the observable determinants of trade are income and policy variables such as FTAs and common currency. The most obvious setting in which we attempt to identify the effects of the container is the gravity model. The gravity equation and its theoretical underpinnings have been discussed in the literature review.

This chapter is an initial investigation into how the effects of containerisation should be modelled: is it annual, 5-year intervals? is it port, port and rail? Also, how robust are the different model estimations?

Following the literature, and as an initial exploration, we begin this empirical chapter by estimating a traditional gravity model in which we identify the effects of containerisation in ports. The (port) container measure is initially a country-year specific variable in section. In sections 5.2-5.6, we consider annual aggregate trade outcomes. Some of the econometric problems faced in this setting are addressed. Namely, we discuss and deal with omitted variables and endogeneity in sections 5.3 and 5.4. We then explore evidence for additional effects for intermodality of containerisation between sea and rail in section 5.6.

As discussed in the literature review, a key implication of the derivation of the gravity equation is that the empirical estimation of traditional gravity equations may be biased. This is because the 'traditional' estimations ignored the multilateral resistance terms.

The literature has come to terms with the problems that arise when omitting the multilateral resistances. Empirically, this has been dealt with by introducing country-year FE. We follow the literature and introduce fixed effects to control for multilateral resistances in section 5.7. In doing so, we consider a pooled panel of 5-year intervals to identify the effects of containerisation. We argue that inclusion of country-time and country-pair FE solves omitted variable bias as a source of potential endogeneity and controls for multilateral prices. We also estimate a first-differenced model. We argue that the first differenced model is the preferred model of estimation as it is less restrictive. We consider the measure for port containerisation but also merge port and railway containerisation - we call this full containerisation - to allow for intermodal transport in our estimations. We also consider bilateral trade outcomes as well as manufacturing trade separately.

We investigate the effects of containerisation in a balanced panel of bilateral trade flows and consider subsamples of North-North, North-South, and South-South trade flows in section 5.8. We argue that estimates of North-North trade are likely to be less prone to bias caused by missing trade observations or measurement error. We also study the effects of the container on (manufacturing) trade separately. Finally, we conclude in section 5.9.

5.2 Containerisation and Bilateral Trade Flows: A Country-level Analysis

5.2.1 Specification and Estimation

Recall that we are interested in studying the effects of the container on international trade. How much of the increase in international trade can be explained by containerisation? We follow the common practice of modelling expected trade using a specification based on the gravity framework. We use annual trade data to identify the effects of containerisation in this section. Given the broad scope of our data, our estimation use panel data methods to take advantage of time and cross-sectional variation in the adoption of the container available to us.

In this section, we only investigate the effects of containerisation in ports on trade flows. In later sections, we include rail containerisation and intermodal transport. In doing so, we estimate a reduced form gravity equation. The reduced form log-linearised gravity equation can be written as:

$$lnX_{ijt} = \beta_0 + \beta_1 portcont_{it} + \beta_2 portcont_{jt} + \beta_3 V_{ijt} + \beta_4 D_{ijt} + u_{ijt} \qquad (5.1)$$

The equation describes the value of total trade (denoted by X) from country i to the destination country j at time t, X_{ijt} as a function of a host of ij-, it-, jt-, ijt-dimensional observable variables (summed by the vector V_{ijt}) and non-observable variables or dummies (summed by the vector D_{ijt}). Port containerisation is captured by the variables $portcont_{it}$ and $portcont_{jt}$ in the above equation. These capture the adoption of containerisation by the originator country i and the destination country j respectively. Information on the container variable and how it is constructed is presented in chapter 4.

Our estimation strategy is to start with a simple estimation of equation 5.1 and then add in more variables and fixed effects to pin down the most appropriate specification.

5.2.2 Country and Country Pair FE

In the first set of regressions, we have 29 years of data points, from 1962-1990 (annual data). The regressors that we use are GDP per capita adjusted for purchasing power (from Penn World Tables) for both countries to capture the supply and demand sides and population to control for the size of both countries. To make use of the time and cross-section variation found in the adoption of containerisation, we introduce two variables to capture containerisation, one for the originator and one for the destination country.

In table 5.1 column 1, regression 1 is estimated with country dummies while regressions 2-9 are estimated with country-pair FE. In all cases we include a set of year dummies to control for year-specific shocks such as the oil crisis and the Suez Canal Closure in 1967-1975. Country dummies in regression 1 capture country time-invariant characteristics such as landlockedness and area among others. With country-pair FE, we are capturing all time invariant country-pair effects. One can think of distance, shared border, common language, common heritage, and other observed and unobserved time-invariant bilateral covariates. Also in columns 2-9, standard errors are clustered by country-pair.

Table 5.1: First estimations of the effects of port containerisation

Dep. Var: ln trade(ij)	(1) entire sample	(2) entire sample	(3) entire sample	(4) entire sample	(5) OECD trade	(6) High Income Trade	(7) Mid Income Trade	(8) Low Income Trade	(9) Intra-OECD Trade
ln gdp per capita(i)	0.638***	0.703***	0.703***	0.681***	0.916***	0.816***	0.742***	0.372***	1.462***
	(0.0214)	(0.0429)	(0.0429)	(0.0430)	(0.0675)	(0.0598)	(0.0471)	(0.0711)	(0.1910)
ln gdp per capita(j)	0.741***	0.821***	0.821***	0.808***	0.896***	0.888***	0.866***	0.605***	1.042***
	(0.0207)	(0.0377)	(0.0377)	(0.0379)	(0.0474)	(0.0446)	(0.0451)	(0.0622)	(0.1883)
ln pop(i)	0.542***	0.687***	0.688***	0.825***	0.946***	0.542***	1.174***	0.548***	0.183
	(0.0479)	(0.0832)	(0.0832)	(0.0875)	(0.1285)	(0.1102)	(0.1025)	(0.1857)	(0.2172)
ln pop(j)	1.102***	1.269***	1.270***	1.327***	1.558***	1.419***	1.425***	1.138***	1.088***
	(0.0465)	(0.0783)	(0.0832)	(0.0817)	(0.0993)	(0.0940)	(0.1027)	(0.1729)	(0.3805)
portcont(i)	0.213***	0.156***	0.149***	0.156***	0.221***	0.205***	0.185***	0.200***	0.083**
	(0.0157)	(0.0183)	(0.0214)	(0.0211)	(0.0300)	(0.0279)	(0.0249)	(0.0377)	(0.0388)
portcont(j)	0.130***	0.112***	0.104***	0.128***	0.124***	0.066**	0.069**	0.244***	-0.002
	(0.0157)	(0.0182)	(0.0226)	(0.0227)	(0.0320)	(0.0305)	(0.0269)	(0.0424)	(0.0440)
portcont(i)*portcont(j)			0.014	-0.091***	-0.080**	-0.052	-0.029	-0.099*	-0.012
			(0.0276)	(0.0276)	(0.0350)	(0.0338)	(0.0325)	(0.0552)	(0.0466)
trend portcont(i)				0.020***	0.000	0.005*	0.022***	0.030***	0.003
				(0.0029)	(0.0031)	(0.0030)	(0.0035)	(0.0061)	(0.0039)
trend portcont(j)				0.012***	0.005	0.006*	0.013***	0.017***	-0.011**
				(0.0030)	(0.0033)	(0.0033)	(0.0036)	(0.0062)	(0.0054)
Countries	127	127	127	127	127	127	127	127	22
Country Pairs	13385	13385	13385	13385	5244	6430	10062	5379	506
Observations	231917	231917	231917	231917	132737	145984	164780	76061	14626
$overall R^2$	0.5185	0.4282	0.4280	0.4287	0.4967	0.4570	0.3935	0.3265	0.5354
Dummies	i,j,t	ij, t	ij,t	ij,t	ij,t	ij,t	ij,t	ij,t	ij,t
Clustering	none	ij	ij	ij	ij	ij	ij	ij	ij
Balanced	No	No	No	No	No	No	No	No	No

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results presented in columns 1 and 2 in table 5.1 suggest that containerisation has a positive and significant effect on trade. In column 1, our country FE estimation suggests that trade is 24%($e^{0.213} - 1$) higher after the originator containerises and 14% ($e^{0.129} - 1$) higher after the destination containerises compared to pre-containerisation trade levels. Adding both effects up suggests that when both partners containerise, trade is close to 38% higher than before containerisation. When we control for country-pair

FE in column 2, the total effect of the container on bilateral trade is 29% (adding up the coefficients of *portcont*(i) and *portcont*(j). In regression 3, we add in an interacted container term (portcont(i)*portcont(j)) to control for any additional effects resulting from both countries containerising on a trade route. The result in regression 3 suggests that there is no additional effect from containerisation when both countries containerise. The coefficient of the interaction term is positive but insignificant. Total effect on bilateral trade is 27% more trade compared to pre-container levels.

In the above results, we have two containerisation variables - one for the originator and one for the destination. We are therefore able to capture an effect when one of the two countries in a bilateral relationship adopts the technology. What does it mean to have only one of the two countries in a trade link containerise? We have mentioned previously that it was necessary to equip containerships with onboard cranes to allow them to call at ports that did not have the facilities to handle containers. This was especially the case at the start of containerisation when only a handful of countries were equipped to handle containers.

Our container dummy captures what we call the level or base effect. To control for any trends in containerisation and to avoid imposing any functional form on the evolution of bilateral trade following containerisation and since we are using annual data, we construct a trend variable. This trend variable acts like a counter and increases by increments of one for each additional year of containerisation. The variable turns one for a country once that country containerises and increases by one each year afterwards. We will call this variable the container trend variable. By constructing this container trend variable, our containerisation effect now comprises a base effect and a trend effect.

We insert our container trend variables in regression 4 and run the same estimation with country-pair FE and year dummies as before. The results suggest a base effect of 31% when both countries adopt the technology. The coefficient of the interacter container variable suggests is now negative. The negative coefficient indicates diminishing savings in trade costs after one country had containerised. This is expected because some of the savings attributed to containerisation especially the reduction in theft and damage are achieved only once either trade partner has containerised. In other words, once the goods have been placed in containers at the beginning of the journey, then savings related to pilferage and damage are already achieved regardless of which country operated a container terminal. As a total effect, when both partners containerise, trade is 22% higher compared to pre-container levels. The estimated coefficients of the trend variables suggest that trade increases annually at an average rate of 2% and 1% respectively when the originator and destination countries containerise. The total container effect becomes as follows. If both the originator and the destination containerise, then the base effect on trade of the container is 22% and the trend effect is 3% annual increase in trade. In other words, assume that two countries containerised in 1969, our model estimates that their trade jumped by the base rate of 22% and continued to grow at a rate of 3% annually thereafter. Also this would mean that by 1990, the two countries' trade would have increased by a total of 88% compared to 1968 level due to containerisation.

Due to the nature of the estimator, the above results are average over the sample countries. One expects that containerisation affected countries differently according to geographical and income considerations. To explore any possible heterogeneities in the sample and whether the results are driven by any sub-sample of countries, we restrict our sample to groups of countries according to their incomes. We divide countries into three groups: high-income, mid-income, and low-income. We regard countries as high-income if their income (GDP per capita) falls in the top 75% percentile as of 1962, low-income if they fall in the lower 25% percentile, and mid-income if they fall in between. Refer to the previous chapter for more information on containerisation and income classifications. We also consider OECD countries separately. In regression 5, we restrict the sample to observations where either trade partner is an OECD country[1]. In regressions (columns) 6, 7, and 8, either partner is a high-income country, a mid-income country, or a low-income country respectively. In regression (9), the sample is restricted to intra-OECD trade only, i.e. observations in which both trade partners are OECD countries.

The results in columns 5 to 9 confirm that containerisation had a significant and positive effect on the trade of all groups of countries when considered separately. The largest benefactors of the introduction of the container seem to be, perhaps surprisingly, low-income countries, followed by OECD countries, and then high and mid-income coun-

[1]OECD countries in our sample are those countries that had joined the OECD by 1990. These are: Australia, Austria, Belgium, Canada, Denmark, Finland, West Germany, France, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and USA. We leave Turkey out since Turkey was a late containeriser unlike the other members.

tries. The base effect of containerisation on the trade of low-income countries is in the magnitude of 41%. In the case of the trade of OECD countries, the base effect on trade is 30%. This result does not hold for intra-OECD trade (column 9), where the base effect of the container is estimated to be much lower at 8% only. This could be because many OECD countries are European countries that trade mainly over land with each other and we only look at port containerisation in this section. The effect of containerisation on the trade of high-income countries is estimated to be 25%. And finally, the effect of the container on the trade of mid-income countries with the rest of the world is around 24%, the coefficient of the interacted container term being insignificant.

As for the container trend coefficients, these seem to be largest for low-income countries as well; a trend of 3% annual growth rate in trade after the containerisation of the originator and 2% after the destination's containerisation. The second largest trend coefficients belong to the mid-income regression. Trade grows at an average annual rate of 2% and 1% after the introduction of the container by the originator and the destination respectively. As for the high-income regression, trade grows at a lower annual rate of 0.5% due to the containerisation of both the originator and the destination. On the other hand, there is no significant container trend in OECD trade.

So in summary to this section, the first estimations of the effects of the container suggest a significant and positive effect of the container on trade in the FE specifications with country and country-pair FE. The effect of the container consists of a base (level) effect and a trend effect. Decomposing the container effect suggests a total base effect in the range of 22%. When allowing for a trend effect, we find that trade grows at an annual rate of around 3% after the introduction of the container by the two partners. This effect is not uniform across all countries. As one might expect, different countries are affected differently by the container. As a preliminary exploration of the heterogeneity of the container effect, we find that containerisation had the biggest impact on low-income countries' trade, followed by OECD countries, and then high and mid-income countries. We will explore the heterogeneity of the container further in the ensuing sections.

5.3 Omitted Variables

Omitted variable bias is an econometric problem that leads to biases in the estimates. The problem occurs when an omitted variable from the regression is a determinant of

Table 5.2: Omitted Variables and Alternative Specifications

Dep. Var: ln trade(ij)	(1) entire sample	(2) entire sample	(3) entire sample	(4) entire sample	(5) entire sample	(6) entire sample (Move Cont 3 yrs back)	(7) entire sample (Move cont 3 yrs forward)	(8) entire sample (Move cont 5 yrs forward)
ln gdp per capita(i)	0.673***	0.681***	0.674***	0.567***	0.457***	0.681***	0.692***	0.704***
	(0.0429)	(0.0430)	(0.0494)	(0.0426)	(0.0462)	(0.0431)	(0.0430)	(0.0429)
ln gdp per capita(j)	0.801***	0.808***	0.783***	0.800***	0.532***	0.800***	0.817***	0.826***
	(0.0377)	(0.0379)	(0.0423)	(0.0352)	(0.0362)	(0.0380)	(0.0378)	(0.0378)
ln pop(i)	0.874***	0.825***	0.398***	0.905***	1.060***	0.829***	0.787***	0.738***
	(0.0882)	(0.0875)	(0.1382)	(0.1157)	(0.1315)	(0.0868)	(0.0887)	(0.0892)
ln pop(j)	1.377***	1.327***	1.282***	0.931***	1.512***	1.313***	1.347***	1.349***
	(0.0821)	(0.0817)	(0.1201)	(0.1015)	(0.1142)	(0.0805)	(0.0830)	(0.0838)
portcont(i)	0.154***	0.156***	0.124***	0.031	0.085***	0.041*	0.241***	0.308***
	(0.0211)	(0.0211)	(0.0243)	(0.0200)	(0.0207)	(0.0232)	(0.0207)	(0.0208)
portcont(j)	0.127***	0.128***	0.142***	0.091***	0.076***	0.078***	0.142***	0.134***
	(0.0227)	(0.0227)	(0.0260)	(0.0214)	(0.0219)	(0.0249)	(0.0228)	(0.0232)
portcont(i)*portcont(j)	-0.084***	-0.091**	-0.079***	-0.055**	-0.078***	-0.051*	-0.093***	-0.090***
	(0.0276)	(0.0276)	(0.0280)	(0.0254)	(0.0249)	(0.0285)	(0.0287)	(0.0294)
trend portcont(i)	0.018***	0.020***	0.013***	0.032***	0.027***	0.023***	0.010***	-0.003
	(0.0029)	(0.0029)	(0.0033)	(0.0039)	(0.0040)	(0.0027)	(0.0032)	(0.0034)
trend portcont(j)	0.011***	0.012***	0.001	0.005	0.016***	0.016***	0.008***	0.004
	(0.0030)	(0.0030)	(0.0037)	(0.0038)	(0.0040)	(0.0027)	(0.0032)	(0.0035)
FTA	0.354***							
	(0.0479)							
Both GATT	0.144***							
	(0.0262)							
Com Cur	0.461***							
	(0.0873)							
Countries	127	127	127	127	127	127	127	127
Country Pairs	13385	13385	13385	13385	13385	13385	13385	13385
Observations	231917	231917	231917	231917	231917	231917	231917	231917
$overall R^2$	0.4271	0.4287	0.3938	0.4516	0.0263	0.4310	0.4237	0.4208
Dummies	ij,t	ij,t, country trend	ij,t,Region-t	ij,t,it,jt (3 decades)	ij,t,it,jt (4 decades)	ij, t	ij,t	ij,t
Clustering	ij	ij	ij	ij	ij	ij	ij	ij
Balanced	No	No	No	No	No	No	No	No

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

the dependent variable and the omitted variable is correlated with one or more of the included independent variables/regressors. The problem can be summarised as follows. One of the classical assumptions of the linear regression model for best linear unbiased estimators is that the error term is uncorrelated with the regressors, i.e. E(Xu)=0. When the omitted variable is not included in the model, then it is moved to the error term. If one of the included variables is correlated with the omitted variable, then the assumption that the regressors and the error term are uncorrelated is violated. This renders the OLS estimator biased and inconsistent. The direction of the bias depends on the estimators as well as the covariance between the regressors and the omitted variables.

In our model, our container variables could be correlated with observable components in the error term such as some policy variables. One can think of FTAs, common currency, and GATT membership. This could be the case if countries that subscribe to a FTA are more likely to containerise for instance. In this case, the OLS estimator may be overestimating the true value of the estimator.

More worryingly is the correlation with unobservable components - for example, a shock to the demand for trade between two countries that causes the countries to containerise. Traditionally, the literature has tended to deal with this problem by introducing FE.

In this section, we will first control for observable omitted variables such as the policy variables and then move to control for unobservable by introducing more FE, other than country-pair and time FE that are already introduced.

Containerisation in equation 5.1 is measured as a country-year specific event. To investigate whether we have any omitted variables, we introduce additional controls for FTAs, common currency, and bilateral GATT membership. We refer to these variables as 'policy variables' in this thesis. The FTA dummy indicates whether the two countries in a given observation belong to the same regional free trade block or are in a free trade agreement in a specific year. For example, before 1973, the UK belonged to the European Free Trade Association (EFTA) which was founded in 1960 by Austria, Denmark, Norway, Portugal, Sweden, Switzerland, and the UK. The UK's membership in EFTA was terminated when the UK joined the European Union in 1973. So our FTA dummy is one for trade between the UK and any of EFTA's other members between 1960 and 1972. In 1973, the dummy would switch to one for trade between the UK and the European Union (EU) members at the time and switch to zero for trade with the remaining EFTA members[2]. The common currency control switches to 1 to indicate whether countries i and j share a common currency in a specific year. We also include an indicator for bilateral membership of the GATT, the precursor of the WTO. The GATT was formed in 1949 and lasted until 1993 when it was replaced by the WTO. The dummy variable 'both GATT' indicates whether both countries are GATT members.

We estimate equation 5.1 with the additional policy controls mentioned above as regressors. In column 1, we include country-pair and year dummies as in table 5.1. The results in column 1 table 5.2 confirm that adding the above controls does not affect the container estimates. The estimates of the coefficients of the container variables are practically unchanged compared to the regression 4 in table 5.1. The FTA estimate of 0.354 is somewhat smaller than Head et al. (2010) estimate of 0.45 and almost half of the coefficient estimate of 0.68 found by Baier and Bergstrand (2007) when including country-pair dummies. Membership to the GATT matters as well. We find that when both countries are GATT members, trade is 15% higher than pre-membership levels.

[2]Denmark left EFTA and joined the EU in 1973 just like the UK.

This is exactly what Rose (2002) obtains for the GATT memberships when he employs country-pair effects. Adding the above country time variant controls does not have any effect on the estimation of the container coefficients. This result suggests that our container variables are not correlated with any of these variables.

In the remainder of this section, we introduce more FE to control for any omitted variable bias coming from unobservable factors. In some sense, we add in more controls to stress-test the results.

In regression 2, we control for country trends. The country trends act as counters and increase by one for each additional years. Since our data set starts in 1962, then the trend variable starts counting from that year. This should control for any trends in trade before and after containerisation. So the container trend will now be significant only if it differs from any pre-existing trend. The results in column 2 do not change at all compared to what we see in table 5.1. Also, we still estimate positive and significant coefficients for the container trends suggesting that the trend we pick up with these variables is different from pre-existing trends.

Other unobservable factors that may have affected trade and may be correlated with the adoption of containerisation are country- or region-time specific. Due to computing capacity constraints, we are unable to include country-year (it and jt) dummies while estimating annual data with the current specification. This would involve 127*29*2 or over 7000 dummies. We go around this in an ensuing section by picking points in time (time intervals) in the panel set. In this section however we try different time FE specifications to test the results further. In regression 3, we introduce region-year effects. In using the region dummies, we identify the effects of the container from the within region variation. We are also assuming that the omitted variables differ between but not within regions. We divide our countries into 9 groups/regions: OECD, Europe Other than OECD, Central and Latin America, Caribbean, Africa, East and South-East Asia, South Asia, Southwest Asia, and Oceania-Pacific. The estimates do not change much. Trade is in total 20% higher than before containerisation. The coefficient of the container trend variables is around 1% for the originator but very small and insignificant for the destination.

Regressions 4 and 5 introduce country-decade FE. Recall that we have a total of 29 years in our dataset. In regression 4, we divide the time period into 3 decades (1962-

1970, 1971-1980, and 1981-1990) and introduce country-decade FE. We include country-decade FE to control for unobservable country-time shocks and given data constraints, this is the most detailed we can go.

The estimates are affected by the inclusion of the country-decade FE. The total effect of the container on bilateral trade is only around 5%. This is substantially lower than the estimates in table 5.1.

Containerisation started in 1966. This means that containerisation is an effect specific to the second half of the 1960s. Also, the years ending with 7,8, and 9 are the most frequent years in which containerisation occurs. This means that splitting our decades differently to account for this fact may be expected to return stronger results. To try this, we divide the period 1962-1990 into 4 decades/time periods: 1962-1965, 1966-1975, 1976-1985, 1986-1990. This produces different results from regression 4. In column 5, table 5.2, in total, trade increases by 9% when both countries containerise. The container trend variables are positive and significant and indicate an annual growth rate of 5% due to containerisation. By controlling for country-decade, we are restricting the effect of the container to within decade (period) variation. The weaker results suggest that our estimates are sensitive to the inclusion of country-time unobservable factors that determine trade. In section 5.7, we introduce country-year FE in a different specification to control for any omitted variable bias coming from unobservable country-time factors.

In the remaining part of the section, we check whether the container has any pre-containerisation or lagged effects. In doing so, we move the containerisation indicators backward and forward in time. In regression 6, we move the container indicators three years backward for all countries. This should control for anticipatory effects of containerisation. In other words, moving the container indicators 3 years backwards should test whether any anticipation of the introduction of the container lead to any pre-container increase in trade. The choice of 3 years is due to the fact that we have only 4 years of pre-containerisation in our data set. The results suggest there is some evidence for anticipatory effects on trade. However the container coefficients are much lower than the contemporaneous container coefficients in previous regressions. In total, trade increases by 7% due to pre-containerisation.

In regressions 7 and 8, we perform a similar exercise to regression 6 above but by moving the container indicators 3 and 5 years forward respectively. This allows containerisation to have effects that are captured 3/5 years after adoption. The choice of 5 years is based on the evidence presented in chapter 4 about the speed of adjustment. The choice of 3 years is for robustness. We look more closely at the lagged effects of containerisation in chapter 6 of this thesis.

In comparison to the contemporary effects of the container in table 5.1, both regressions return stronger effects for containerisation suggesting that containerisation had lagged effects 3 and 5 years later. In regression 7, total effect of the 3-year lagged container variables is 33%. As for regression 8, total effect of the 5-year lagged container variables is 41% which is higher than the total effect estimated for the 3-year lagged effect. This is compared to a total contemporaneous effect of 22%. As for trends, we pick up lower trend coefficients in regression 7 of around 1% for each the originator and the destination. We pick up virtually no trends when containerisation is moved 5 years forward in regression 8.

To summarise, in this section, we attempt to deal with potential omitted variable bias. We do so by including policy variables that may be correlated with the container measures. We find that controlling for FTAs, GATT membership, and common currency does not change the estimated effects of containerisation in equation 5.1. We also attempt saturating the regressions by including more FE to control for unobservable factors that may be correlated with containerisation. The evidence suggests that the estimated coefficients are sensitive to the inclusion of unobservable region and country-time FE. There is also evidence that containerisation may have small anticipatory effects of trade but much larger lagged effects.

5.4 Endogeneity

In this section, we deal with the potential problem of endogeneity in our estimation equation (equation 5.1). Is containerisation truly exogenous or does our estimation suffer from endogeneity bias? Since we do not have an instrument, we restrict the sample to consider parts of the data where endogeneity may be less of a concern.

A standard problem in econometric models is the potential endogeneity of RHS (right hand side) variables. There are three possible sources of endogeneity: omitted variable bias, simultaneity bias, and measurement error. We discussed the problems that can arise when relevant variables are omitted in the previous section and we turn back to it in section 5.7 where we propose a different specification to account for them. The source of endogeneity that we refer to here is simultaneity bias / reverse causality.

It can be argued that the decision to containerise in a given country depends partially on the volume of bilateral trade flows. In other words, if France is one of Vietnam's main trade partners, would France's containerisation make the Vietnamese containerise faster? In order to answer this question, we need to recall some facts about containerisation. Containerisation is a process that requires such high capital investments that it might not make economic sense for a country to introduce it just because of one specific trade route. Most countries trade with several countries and most countries have more than one major trade partner. In our dataset, without accounting for missing observations, each country trades on average with 63 other countries per year.

The investments in capital to allow containerisation to occur are large. Containerisation started as a private endeavor by the shipping lines. In the early stages, shipping lines had to bear most of the costs since many ports such as New York and London were reluctant to spend on what could be a failing undertaking. Many shipping lines had to operate from small and formerly unknown ports and install their own cranes. The process was extremely expensive. The UK had to spend close to £200 million between 1966-1969 just on a few ports not to mention rail and road expansions (McKinsey and Company (1967)). Rotterdam alone spent close to $60 million on its container terminal. After the container gained ground on the major shipping routes, ports warmed up to containerisation and a race started among ports to attract the most shipping lines by building new terminals and providing the infrastructure to handle containers. There is evidence that suggests containerisation led to the rise and fall of ports as we discuss in chapter 2.

Certainly in the beginning, the decision to containerise by a port was a strategic decision. Many ports in Europe and the United States raced to containerise to attract shipping lines to call at them. In New York, the decision of the port not to containerise led to its demise. Port Elizabeth and Newark in New Jersey became successful due to their decisions to invest in container facilities. In Europe, the ports of Rotterdam and Bremen were fast to adopt the new technology and this is why Sea-Land chose to call at them on its first transatlantic trip. In the UK, the London Docks vanished while

Felixstowe, a privately owned port, flourished following its decision to operate purely as a container port.

In many countries, port authorities fall under the administration of the government. Due to the high costs, careful planning and analysis had to be undertaken by governments to study the feasibility of containerisation. In the UK, the government commissioned McKinsey to make a cost and benefit analysis before it embarked on a programme of containerisation that had cost hundreds of million pounds in that period's money. We were surprised to find that nowhere in the report was there a mention of promoting a specific trade route being a reason to containerise. The McKinsey report focused solely on cost savings and potential economies of scale brought about by the container and how these would benefit UK trade in general.

5.4.1 Dealing with Endogeneity: Methodology

Although, as we argue above, the narrative does not suggest that our specification should suffer from severe reverse causality, we still attempt to deal with any concerns however. We do this mainly by addressing the sources of the possible reverse causality and then restricting the sample to parts where endogeneity is less of a concern.

In our first exercise, we address the possible decision to containerise coming from large bilateral trade flows. We calculate the share of bilateral trade flows in total trade for all countries in our sample. Exports and imports are considered separately. Averages of bilateral trade flows are calculated over the entire period of our sample (1962-1990). The average bilateral flows are then divided by average total exports or imports of a country to determine the shares of trade. We then remove trade observations relating to the top 5 exporters and importers of a given country. This leaves us with those observations that are less likely to have big impact on a country's decision to containerise. For instance, Belgium's top 5 importers are USA, France, West Germany, Netherlands, and the UK. Belgium's top 5 exporters are the same as its importers. All observations relating to Belgium's trade with these countries are excluded.

Eliminating the main trade partners from the sample as described above leaves us with 207,415 observations and 12,467 country pairs. We estimate the same model as in regression 4 table 5.1 (with country-pair and year FE). The result of regression 1 table 5.3 is consistent with what we see in table 5.1 regression 4. We still estimate a total

Table 5.3: Endogeneity and Heterogeneity

Dep. Var: ln trade(ij)	(1) Removing Top Trade Partners (Avg 1962-1990)	(2) Removing Top 5 Trade Partners in 1962	(3) Removing Top 5 Trade Partners in 1990	(4) Either Partner is Land-locked	(5) Landlocked Destina-tions only	(6) Landlocked Origina-tors only	(7) Both Land-locked	(8) Island Countries
ln gdp per capita(i)	0.600***	0.641***	0.604***	0.870***	0.766***	1.254***	1.251***	0.678***
	(0.0456)	(0.0463)	(0.0458)	(0.1106)	(0.1480)	(0.1512)	(0.4452)	(0.0431)
ln gdp per capita(j)	0.801***	0.822***	0.813***	0.988***	1.176***	0.788***	0.720*	0.813***
	(0.0406)	(0.0408)	(0.0414)	(0.0813)	(0.1309)	(0.1021)	(0.3731)	(0.0380)
ln pop (i)	0.753***	0.813***	0.737***	1.272***	0.902***	1.970***	1.398**	0.856***
	(0.0934)	(0.0942)	(0.0945)	(0.2037)	(0.3168)	(0.2400)	(0.6763)	(0.0872)
ln pop (j)	1.380***	1.327***	1.415***	0.889***	0.993***	0.823***	-0.882	1.282***
	(0.0882)	(0.0882)	(0.0898)	(0.1759)	(0.2639)	(0.2471)	(0.6673)	(0.0826)
portcont(i)	0.133***	0.118***	0.143***	0.139***	0.125*	0.177**	0.180	0.127***
	(0.0227)	(0.0231)	(0.0230)	(0.0503)	(0.0670)	(0.0713)	(0.1940)	(0.0233)
portcont(j)	0.125***	0.136***	0.140***	0.031	0.002	0.115	0.153	0.167***
	(0.0243)	(0.0249)	(0.0247)	(0.0547)	(0.0708)	(0.0787)	(0.2092)	(0.0248)
portcont(i)*portcont(j)	-0.090***	-0.074**	-0.099***	-0.044	-0.015	-0.113	0.067	-0.093***
	(0.0300)	(0.0306)	(0.0306)	(0.0610)	(0.0814)	(0.0858)	(0.2493)	(0.0281)
trend * portcont(i)	0.024***	0.026***	0.023***	0.040***	0.046***	0.035***	0.056***	0.020***
	(0.0031)	(0.0031)	(0.0031)	(0.0057)	(0.0108)	(0.0060)	(0.0175)	(0.0029)
trend * portcont(j)	0.013***	0.014***	0.011***	0.026***	0.017***	0.035***	-0.015	0.012***
	(0.0032)	(0.0032)	(0.0032)	(0.0057)	(0.0064)	(0.0105)	(0.0187)	(0.0030)
portcont(i)*island(i)								0.121***
								(0.0379)
portcont(j)*island(j)								-0.154***
								(0.0378)
portcont(i)*portcont(j)*island(i)*island(j)								0.046
								(0.0699)
Countries	127	127	127	127	127	127	21	127
Country Pairs	12467	12411	12373	3128	1672	1644	188	13385
Observations	207415	204748	204117	45194	24646	23028	2480	231917
$overall R^2$	0.3645	0.3737	0.3504	0.4750	0.5154	0.5311	0.2913	0.4352
Dummies	ij,t	ij,t	ij,t	ij,t	ij,t	ij,t	ij,t	ij,t
Clustering	ij	ij	ij	ij	ij	ij	ij	ij
Balanced	No	No	No	No	No	No	No	No

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

effect for the container of 18% on trade.

In regressions 2 and 3, we repeat the same exercise as above. However, instead of averaging bilateral trade flows over the entire period, we calculate the shares of bilateral trade in total trade for each country in 1962 and 1990 respectively. In estimating regression 2, we remove the top 5 exporters and importers of each country in the sample in 1962. In estimating 3, we do the same but for 1990. The results are roughly similar to what we see in regression 1.

These results support our prediction that large bilateral trade flows should not affect the decision to containerise, at least not to a big extent. A country will containerise only if it had realised the need for it and it had secured the capital to do so. The private sector is as crucial to the process as the public sector is. The private sector needs to invest in very expensive containers and container ships. This means that the poorer a country is, the slower it will containerise. We have seen earlier that low income countries were last to containerise. Also, country size and remoteness govern whether it is feasible for shipping lines to call at. This is why a country like the Comoros Islands remained largely uncontainerised in the late 80s. In short, it is very likely that the decision to containerise is determined by several factors other than bilateral trade flows.

The second endogeneity treatment we attempt concerns solely landlocked countries. It can be argued that containerisation is exogenous to landlocked countries. Containerisation was imposed on landlocked countries and they had little say in the process. Many landlocked countries were forced to adapt to the new technology by constructing inland container depots and railway stations to get their goods in containers to the nearest container port over the border. The use of containers on the railway will be modelled later. We see this process of adaptation most clearly in countries like Austria and Switzerland. How did containerisation affect the trade of landlocked countries?

To answer the above questions, we perform a series of empirical exercises. In the first exercise, we restrict our sample to observations in which either the originator or the destination is landlocked (or both)[3]. This leaves us with 45194 observations and 3128 country pairs. Since landlocked countries do not have access to the sea, they are naturally uncontainerised. However, to trade with remote countries, landlocked countries have to use the ports of their non-landlocked neighbours. In regressions 4-7 of table 5.3, we allow for landlocked countries to containerise once their nearest port country containerises. We do this by having the containerisation variables of the landlocked countries reflect the state of containerisation in the country with the nearest port to them. For instance, for Austria, the nearest country with a coastline would be Italy and for Burundi, it would be Tanzania, etc. In the event that a landlocked country borders more than one non-landlocked countries, we look at the distance from the capital of the landlocked country to the main container port in each of the adjacent countries and take the shorter distance[4].

In regression 4, we restrict the sample to observations in which either the originator or the destination is landlocked. By doing this, we investigate the effect of the use of containers on the trade of landlocked countries, regardless of whether the landlocked country is the originator or the destination. Recall that we allow landlocked countries to use the nearest container port in the most adjacent country for trade with overseas. We estimate equation 5.1 with country-pair and year effects. We still estimate positive and

[3]Landlocked countries in our data sample are: Afghanistan, Austria, Bolivia, Burkina Faso, Burundi, Central African Republic, Chad, Czechoslovakia, Hungary, Laos, Malawi, Mali, Mongolia, Nepal, Niger, Paraguay, Rwanda, Switzerland, Uganda, Zambia, and Zimbabwe - a total of 21 countries

[4]We consult Google Earth for distance calculations.

significant effect of the exporter's containerisation on trade but only a small positive and insignificant effect of the destination's containerisation. In magnitude, trade increases by 15% when the landlocked or non-landlocked exporter starts using containers. The coefficient of the interacted container variable is negative but insignificant. In total, trade increases by around 15% when both partners containerise. This is less than the total base effect of containerisation found in table 5.1. The container trend effect is bigger however. Trade grows at an annual rate of 4% when the originator containerises and 3% when the destination containerises.

To further investigate the effect of containerisation on the trade of landlocked countries, we restrict our sample to landlocked destinations to isolate landlocked countries' imports. This means that all country j's are now landlocked countries. In column 5, the result suggests that landlocked countries' imports are affected by the originators' use of containers to some extent. The coefficient of the originators' container variable is positive and significant at the 10% significance level. Trade increases by 13% after the originator's containerisation. Recall that the originator could be a landlocked or non-landlocked country in this exercise but the destination can only be landlocked. There is no evidence that the landlocked destination's use of the nearest container port has any effect on their imports. This suggests that the originator's containerisation is more crucial in increasing imports to landlocked countries which is perhaps intuitive. The marginal effect of the second country containerising is negative but small and insignificant. The trend effects of containerisation on imports to landlocked countries are however positive and relatively big. Imports grow at an annual rate of 5% if the originator containerises and 2% if the destination containerises.

To isolate landlocked originator's exports, we now restrict our sample to landlocked originators only. There is evidence that exports of landlocked countries benefited from the containerisation of their near non-landlocked neighbours. In column 6, exports of landlocked countries jump by 19% upon the containerisation of their nearest neighbours. The coefficient of the destination container variable is positive but insignificant and is wiped out by the coefficient of the interacted container variable. The use of the container by the landlocked countries by using the nearest container port across the border is what matters for their exports. The trend variables are both positive and significant at the 1% significance level. Trade grows at an annual rate of 4% due to the use of the nearest port by the landlocked originators and a similar 4% due to the containerisation of the destination countries.

To look at the effect of containerisation on landlocked countries' trade among each other, we restrict the sample to landlocked originators and destinations in column 7. We are left with 2480 observations and 188 country pairs. Results suggest that containerisation may have had some effect on trade between landlocked countries although the effect is not well-identified. Both coefficients of the container variables are positive but insignificant. The coefficients of the trend variables suggest that trade grows at an annual rate of 6% when landlocked originators use the container ports of their nearest neighbours. No such trend is found when the landlocked destinations start using containers.

To summarise, in the section, we consider the potential problem of endogeneity in estimating the effects of the container as modelled in equation 5.1. Since we lack an instrument, we consider sub-samples in which endogeneity is less a concern. The first exercise in this respect consider the largest trade partners and drop the observations related to these trade partners. The rationale behind this is that countries may select into containerisation if their largest trade partner adopt the technology. We find no evidence for this in our estimations in this section. In the second set of estimations, we look at the effect of the use of the container on landlocked countries, where endogeneity is less a concern. We find evidence for an effect of containerisation on the trade of landlocked countries even if they had no say in containerisation themselves. We find a bigger effect of containerisation on their exports than their imports to the rest of the world. The effect on the trade between landlocked countries is positive but not well-identified. The results here suggest that containerisation may have had spillovers that benefitted landlocked countries. This is an important result because while containerisation is exogenous to these countries their trade seems to have benefited from containerisation.

5.5 Heterogeneity: Island Nations

After having looked at the effects of the container on landlocked countries, we now turn to island countries. These are nations that depend purely on shipping to conduct their trade. A country like France shares land borders with many countries and thus conducts most of its trade by rail and by road. The UK, an island nation, on the other hand, is dependent entirely on the sea for the its trade. This is especially true before the proliferation of air cargo and the opening of the Euro Tunnel[5]. One would expect different effects of containerisation on island countries. In fact, one might expect bigger effects on their trade since more of their trade moves through ports. To test this, we construct two island dummies, one for the originator and one for the destination. We then add a number of interaction terms between the container variables and the island dummies. In column 8 of table 5.3, we find a total base effect of 23% of containerisation. This is similar in magnitude to what we find in the regression 4 in table 5.1. Looking at the coefficients of the island-container interaction terms suggest the following[6]. If the originator is an island country and starts using containers, then its exports would increase by an additional 13%, making the total effect of containerisation on the exports of the island originator 27% (adding up the coefficients of the container(i) and island(i)*container(i) variables). If the destinations are containerised but not island nations, then the variables container(j) and container(i)*container(j) switch on. The total base effect of the island originator's use of the container would then be around 36%. This is interesting because it suggests that the increase in exports of island nations due to containerisation is double the average increase in the exports of the non-island containerisers. On the other hand, if only the destination island containerises, then there is a small impact on their imports. The magnitude of the increase in their imports is around 4% from non-containerised originators (the variables container (j) and island(j)*container(j) switch on). Finally if both countries are islands and start containerising, then all variables switch on in the regression (container(i), container(j), container(i)*container(j), island(i)*container(i), island(j)*container(j)). Adding up all coefficients results in an increase of 21% in intra-island trade due to containerisation. This is close to the total base effect found in our table 5.1, regression 4.

In summary, perhaps in line with expectations, we find that an island country can increase its exports on average twice as much as a non-island country would do by containerising.

[5]Refer to figure 4.9 in chapter 4.

[6]Dummies for island status of countries i and j are included in the regression but these drop out due to multicollinearity.

5.6 Containerisation and Intermodal Transport

Countries that share a common border conduct their trade mostly by road or rail. Experts in the transportation and shipping sectors are of the opinion that containerisation's real value is in its intermodality, i.e. its capacity to be used in all transportation modes indiscriminately[7]. Intermodal transport is the term used for allowing goods to be shifted among the three main transport modes with relative ease. Containerisation allowed goods to be transported quickly to and from the port by rail or truck. The container can be transported as a trailer on wheels by trucks and lorries or on wagons by trains. This meant that in order to benefit the most from containerisation, countries had to link their ports with the rest of the country through a comprehensive transport system.

In many countries, containerisation was putting pressure on the existing road networks as trucks have become bigger to transport 20 foot and 40 foot containers. This is why some countries had to invest in their transport infrastructure to cope with the increased traffic on their roads and railways. In the US, this was known as the Federal-Aid Highway Act of 1956. Also railways had to invest to improve their rails to compete with the trucking sector and to build inland container depots and terminals to handle and transfer containers.

Due to the above, one expects containerisation to have spill-overs on the larger economy and on trade. Our data set and model setting allow us to test for spill-over effects on the transport system in countries that start containerisation. One way to look at this is by looking at how containerisation affected the trade between 2 adjacent countries (countries with common border). If port containerisation had led to improved rail and road connections internally, then trade between two countries that share a border should be affected by containerisation even if their trade does not pass through ports. Trade between 2 adjacent countries mostly goes by rail or road. To investigate this, we construct a common border dummy and interact this dummy with the port container variables. We introduce the interacted variable into equation 5.1 and estimate the equation as before. In column 1 table 5.4, the coefficients of the container variables and their trends are similar in magnitude to the estimate in regression 4, table 5.1. As for

[7] Refer to the introduction of chapter 4.

the interacted container and border variable, the coefficient is positive but insignificant.

In column 2 of table 5.4, we interact the container variable with the border dummy and a variable that indicates whether the two countries are OECD countries. The reason we do this is because railway containerisation was mainly introduced in OECD countries in the early stages of containerisation as we discuss in chapter 4. Also, most intra-European trade takes place inland and thus it is most likely to be positively affected by the container. Our reasoning is confirmed by the results. In column 2, containerisation had an additional effect on the trade of OECD countries that share a border in the magnitude of 47%. This quite large result confirms the spill-overs of the new technology on the trade of adjacent countries even if their trade does not go through ports.

To explore this further, we use the data collected about the container proliferation in railways we discussed in the previous chapter. To study the effects of the introduction of containerisation on the railway, we first introduce railway containerisation as separate variables in equation 5.1. We will call these variables 'infra(i)' and 'infra(j)'. The railway or infrastructure indicator variables capture the introduction of the container on the railway in each country. A country's railway container dummy switches on when that country's railways start handling containers. The variables are similar in nature to the port container variables. We also add in an interacted infrastructure variable. The results are presented in column 3 table 5.4. Introducing the infrastructure variables wipes out the port container effects. The introduction of the container on the railway increases trade by around 59% if introduced by the originator and by around 39% if introduced by the destination. When both countries have introduced container on the railway, then total effect is around 74% increase in trade. We no longer estimate significant coefficients for the port container variables. This could be because the infrastructure variables are partially collinear with the original container variables and capture the original effects the port container variable as well as any additional effects from carrying containers by rail. To put this into perspective, the base effects of the container in table 5.1 were around 22% when the entire sample of countries is considered. This suggests substantial additional effects of the container on trade through its introduction on the railway.

Just as our model allows us to test whether introducing containers in ports was found to have additional effects on countries that share a border, similarly, it also allows us to test whether introducing containers on the railway affected countries that share borders more than those that do not. To do so, we simply introduce an interacted infrastructure variable with the border dummy and estimate the same model. Indeed, in column 4 table 5.4, we find that countries that share a border benefit more from containerisation on the railway. This is because trade by rail is only possible inland and makes most sense for countries that share a border together. The model estimates that countries that share a border benefit by an additional 22% increase in their bilateral trade flows on top of the effects estimated in the previous regression.

As a last exercise on this topic, we merge the port container and railway container dummies in our estimation equation. We merge port and railway container variables so that a country is considered containerised whenever its ports or railways start handling containers whichever comes first. In other words, we allow for intermodality in containerisation albeit on ship and rail only. This has the advantage of allowing landlocked countries as well as non-port containerised countries to use their existing railway system to transport containers to adjacent countries and subsequently overseas. We argue that this is a better way of allowing for intermodality between ships and rail because what we see in practice is that a mixture of the two modes of transport is used. Also, countries that first containerised by rail could transport containers to the nearest port over the border to trade with overseas. Following this reasoning, our container variable becomes as follows:

$$Cont_{it} = \begin{cases} 1, & \text{country i has either containerised ports or railways at time t} \\ 0, & \text{otherwise} \end{cases}$$

We call this merged container variable 'full container' variable. We replace the port container variable with the full container variables in our estimation equation 5.1. In table 5.4 column 5, the estimation suggests stronger effects of containerisation on trade when we account for railway containerisation compared with port containerisation only. When the container is introduced by both countries, then the total base effect of containerisation at around 30%. This is higher than the base effect found in table 5.1 (regression 4). The coefficients of the container trend variables remain roughly the same.

In conclusion to this section, we have tried to answer the question whether the spill-over effects of containerisation on the broad infrastructure of the introducing countries translated into additional effects on trade. We try estimating different specifications in which we try to measure and incorporate the spillovers of containerisation. The evidence from these estimations suggests that containerisation that started with ports had additional spill-over effects on trade that were transmitted through improvements and investments in the inland transport infrastructure of port-containerised and landlocked countries.

Table 5.4: Spill-Over Effects of the Container

Dependent Var: ln trade(ij)	(1) entire sample	(2) entire sample	(3) entire sample	(4) entire sample	(5) entire sample
ln gdp per capita(i)	0.681***	0.682***	0.683***	0.683***	0.682***
	(0.0430)	(0.0430)	(0.0424)	(0.0425)	(0.0431)
ln gdp per capita(j)	0.808***	0.809***	0.806***	0.806***	0.798***
	(0.0379)	(0.0379)	(0.0373)	(0.0373)	(0.0379)
ln pop (i)	0.823***	0.832***	0.960***	0.964***	0.867***
	(0.0874)	(0.0876)	(0.0888)	(0.0889)	(0.0979)
ln pop (j)	1.325***	1.333***	1.366***	1.370***	1.416***
	(0.0817)	(0.0818)	(0.0817)	(0.0818)	(0.0879)
portcont(i)	0.154***	0.155***	0.025	0.025	
	(0.0211)	(0.0211)	(0.0219)	(0.0219)	
portcont(j)	0.127***	0.128***	0.031	0.031	
	(0.0227)	(0.0227)	(0.0239)	(0.0239)	
portcont(i)*portcont(j)	-0.093***	-0.092***	0.004	0.004	
	(0.0277)	(0.0276)	(0.0278)	(0.0278)	
portcont(i)*portcont(j)*Border	0.168				
	(0.1021)				
portcont(i)*portcont(j)*Border*oecd		0.388***			
		(0.0792)			
trend * portcont(i)	0.020***	0.020***	0.013***	0.013***	
	(0.0029)	(0.0029)	(0.0029)	(0.0029)	
trend * portcont(j)	0.013***	0.012***	0.008***	0.008***	
	(0.0030)	(0.0030)	(0.0030)	(0.0030)	
infra(i)			0.461***	0.460***	
			(0.0272)	(0.0272)	
infra(j)			0.329***	0.327***	
			(0.0301)	(0.0302)	
infra(i)*infra(j)			-0.263***	-0.268***	
			(0.0359)	(0.0361)	
infra(i)*infra(j)*Border				0.196**	
				(0.0819)	
full cont(i)					0.206***
					(0.0221)
full cont(j)					0.176***
					(0.0243)
full cont(i)*full cont(j)					-0.131***
					(0.0279)
trend*full cont(i)					0.018***
					(0.0036)
trend*full cont(j)					0.016***
					(0.0033)
Countries	127	127	127	127	127
Country Pairs	13385	13385	13385	13385	13385
Observations	231917	231917	231917	231917	231917
$overall R^2$	0.4292	0.4337	0.4335	0.4331	0.4286
Dummies	ij,t	ij,t	ij,t	ij,t	ij,t
Clustering	ij	ij	ij	ij	ij
Balanced	No	No	No	No	No

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.7 Gravity and Multilateral Resistances

After the derivation of a structural gravity equation from CES preferences and based on a general equilibrium framework by Anderson and van Wincoop (2003), empirical studies of international trade flows had to take account of multilateral resistances. Equation

3.2 tells us that bilateral trade flows depend on bilateral trade barriers between i and j relative to the product of their multilateral resistance terms, after controlling for size. For a given trade barrier between i and j, higher barriers between j and its other trading partners will reduce the relative price of goods from i and thus raise imports from i. In other words, trade between countries i and j depends on the trade barrier between them relative to average trade barriers that both regions face with all their trade partners. The expressions of the multilateral resistance terms are given in equations 3.3 and 3.4.

It should be clear that multilateral resistance terms are functions of trade costs t_{ij}. Since trade costs are correlated with the multilateral prices, then estimations of the effects of trade costs that ignore multilateral prices suffer from omitted variable bias.

Since it is not easy to calculate or estimate multilateral resistances, economists have tended to include country FE in cross-sectional studies, country-time effects in panel settings to deal with this problem. We follow suit and include country-time FE in this section.

5.7.1 Multilateral Resistances in the Estimation Equation

To account for multilateral resistance in line with theory, we need to introduce country-year dummies (it and jt) in equation 5.1. However, introducing country-year dummies turns out to be problematic to the previous empirical strategy and our constructed container variable. Recall that we measured containerisation as a country variable that is time-variant in the previous sections. So controlling for multilateral resistances through the use of country-year dummies will wipe out the container effect. Since the country-time effects are collinear with the opening of container port facilities and/or adoption by rail, we can only estimate the effects of containerisation when origin and destination countries both containerize. So this means that we are only able to capture the effect of the container when both parties in a bilateral trade relationship containerise. In other words, our container variable becomes a country-pair time-variant variable (ijt). Now since one-sided containerisation might have had an effect on trade, the total effect of containerisation measured through the bilateral variable might be an underestimate of the true effects of containerisation.

On the practical side of things, introducing country-time dummies means that we need to introduce 157*2*29 or 9106 dummies. This is where you hit a limit on the computing capacity of the statistical software available, Stata in our case. To get around this, we choose data points spaced at 5-yearly intervals starting from 1962 to 1987 and add 1990 as the final data point. The adoption of containerisation started in 1966 and ended in 1983. So our chosen period includes at least one data-point of 'pre-containerisation', the main containerisation period for all countries, and at least a further 2 observations of 'post-containerisation' trade. This reduces the dummies that we need to introduce to 157*2*7 or 2198 dummies only.

Choosing 5-year interval time points turns out to be convenient for another reason. As discussed in the previous chapter (refer to section 4.3), evidence suggests that it takes a few years for trade to adjust fully to containerisation. So with 5-year intervals, we allow time for adjustment and hence we are in a better position to capture the effects of containerisation. By introducing the bilateral container measure, our reduced form gravity specification becomes:

$$lnx_{ijt} = \beta_0 + \beta_1 Cont_{ijt} + \beta_2 \overrightarrow{Policy_{ijt}} + \beta_3 \overrightarrow{V_{ij}} + \beta_4 \overrightarrow{D_{ijt}} + u_{ijt} \tag{5.2}$$

Our container variable is now bilateral time-variant ($Cont_{ijt}$). $Policy_{ijt}$ is a vector of policy variables that are ijt-variant (country-pair time) and these are FTAs, GATT membership, and common currency as mentioned before. V_{ij} is a vector of gravity controls that are bilateral but time invariant such as distance. D_{ijt} is a vector of all it, jt, ij dummies. u_{ijt} is the error term in this model.

Returning to country-time dummies, introducing these dummies allows us to control not only for multilateral resistances but also variables such as GDP, population, and other observable and non-observable time-varying factors that might be correlated with the countries' decision to invest in container ports. Similar to previous estimations, including country-pair FE control for distance, language as well as difficult to measure geographic factors, like government desires to act as container port hubs. Wooldridge (2010)[8] asserts that FE estimations is a useful tool for policy analysis.

We also choose to estimate the above equation in first-differenced model as a robustness check and to allow the ij dummies to vary over time. According to Wooldridge (2010) (page 320), first differencing a structural equation is a simple yet powerful method of programme evaluation. Wooldridge also notes that the first-differencing estimator is

[8]Wooldridge (2010) chapter 10.

more efficient under the assumption that the error terms are serially correlated[9]. Our estimation equation then becomes:

$$\Delta lnx_{ijt} = \beta_0 + \beta_1 \Delta Cont_{ijt} + \beta_2 \Delta Policy_{ijt} + \beta_3 \overrightarrow{D_{ijt}} + u_{ijt} \quad (5.3)$$

We test for serial correlation in the above model using the command xtserial (see Drukker (2003)). The test strongly rejects the null hypothesis of no serial correlation. The result of the test suggests that using first-differencing would correct for serial correlation and hence produce more efficient estimates. The result of the test is included in appendix B.

Another advantage of the above specifications is that they allow for a "horse race" between the technology and the policy variables. This allows us to compare between the effects of technology and policy variables.

5.7.2 FE and Sources of Endogeneity

An important concern that arises when trying to identify the effects of containerisation on trade flows is their possible correlation with the error term, such that the variable is endogenous and therefore OLS yields biased and inconsistent coefficient estimates. As discussed by Baier and Bergstrand (2007) in the context of the effect of FTAs on trade, of the potential sources of endogeneity bias (omitted variables, simultaneity and measurement error) perhaps most important is the potential omission of other relevant variables. We anticipate that there will be both a country-time and bilateral component to this bias.

Containerisation started as a private endeavor by the shipping lines. In the early stages, shipping lines had to bear most of the costs since many ports such as New York and London were reluctant to spend significant funds on 'a new technology' with uncertain returns at the time. Many shipping lines had to operate from small and formerly unknown ports and install their own cranes. The process was extremely expensive. After the container gained ground, ports warmed up to containerisation and a race started among ports to attract the most shipping lines by building new terminals and providing the infrastructure to handle containers. In many countries, port authorities fall under the administration of the government. Because of the high costs, careful planning and

[9] Wooldridge (2010) chapter 10.

analysis had to be undertaken by governments to study the feasibility of containerisation. In the UK, the government commissioned McKinsey & Co to conduct a cost and benefit analysis before spending significant public funds on containerisation. The McKinsey report focused on the cost savings and potential economies of scale brought about by the container and how these would benefit UK trade in general (McKinsey and Company (1967)).

This suggests that the decision to invest in container facilities is likely to be affected by the government beliefs about the trade potential of a country relative to current levels and may change over time with changes to the ruling party's attitude towards free trade and port inefficiencies. These are also factors that are likely to affect difficult to measure aspects of the broader domestic policy environment which are likely to affect trade flows. We control for such effects though the inclusion of country-time dummies for both country i and country j in the estimation of equations 5.2 and 5.3.

While the decision to invest in container port facilities is potentially affected by omitted country-time factors that also affect trade, there may also be a bilateral component to this investment. The location for container port facilities by a country are likely to be affected by geographic factors, they require deep water channels for example, as well as domestic and foreign demand considerations. For example, the first container port facilities in Italy were located in Genoa, in part because Northern Italy is a major centre of industrial production but also in order to provide easier access to the Western Mediterranean and the Atlantic sea routes and in order that this port would be used to serve Austria and Switzerland with containerised goods. More generally containerisation has displayed a hub-and-spoke pattern: large container ports at Rotterdam, Hong Kong and Singapore are used as hubs from which to serve smaller ports. The location of container port facilities in one country may therefore affect the location chosen for container port facilities by later adopters. This may lead to a positive correlation between the location of container port facilities and the error term in the gravity model and therefore a need to control for all observable and unobservable determinants of trade flows between two countries to prevent an upward bias on the containerisation variable. We control for this in the regressions by including country-pair FE similar to the annual data estimations in previous sections.

The effects of containerisation are therefore identified in our empirical framework using the within country-pair variation in trade following the start of containerised trade by both countries, conditional on common changes to trade with other countries in that time period for the importer and exporter. We also note that FE specifications have also been used to avoid omitted variable biases associated with multilateral resistance terms identified from the structural approach to gravity (refer to the literature review, Bergstrand and Egger (2011), and Feenstra (2004)). The inclusion of country-time as well as country-pair FE in the gravity model removes the need to include all time varying country specific factors such as GDP and GDP per capita, as well as time invariant country-pair specific factors such as distance, border dummies, common language etc. A disadvantage of this approach is that the effects of containerisation are determined only when the two countries containerise in different time periods (where they occur in the same time period the effect is captured by the country-time effects). If both countries adopting the technology in the same time periods has a different effect to trade volumes compared to when they differ this will affect our estimated effect of containerisation. The use of fixed-effects also suggests that countries that never containerise could be excluded from the sample. We include them in order to improve the efficiency with which the country-time effects are estimated. Also, since our specification resembles a difference-in-difference estimation equation, then non-containerised countries will serve as a counterfactual in identifying the effects of containerisation.

5.7.3 Empirical Results

Table 5.5 contains the results for estimating equations 5.2 and 5.3 for total trade and a subset of total trade. To reduce any issues surrounding differences in the composition of containerisable versus non-containerisable products across countries, we concentrate our analysis on SITC 1-digit industries 6 and 8 (combined), where such issues are less likely to feature. Refer to chapter 4 (section 4.8) for a discussion on the containerisability of products. Industries 6 and 8 are two 'containerisable' industries according to our containerisability classification at the 1-digit disaggregate level. Our data is not classified along the lines of economic activities (as in ISIC classification). However, industries 6 and 8 are both pure manufactures and 'highly' containerisable[10].

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[10]SITC 1-digit Industry 6 - Manufactured goods classified chiefly by material; 8 - Miscellaneous manufactured articles.

is also advantageous because we can test whether those effects differ by product as one may expect. In the next chapter, we will allow this effect to differ by product at the SITC disaggregate product level. We will consider product level econometric models in which the dependent variable has an additional product dimension lnx_{ijkt}.

Hence, we estimate equation 5.2 (FE model) for total trade and industries 6 and 8 including country-time effects in columns 1 and 4 respectively and add bilateral dummies in columns 2 and 5, while we estimate equation 5.3 (first differenced) in columns 3 and 6.

When considering the two SITC industries, our dependent variable is still lnx_{ijt} but it is now the aggregated bilateral trade flows in industries 6 and 8 combined together. For now, we will refer to these two industries as 'manufacturing' for convenience.

Our results suggest positive and significant effects from containerisation that is stronger for manufacturing compared to total trade and is stronger when its effects are identified by exploiting the between country-pair variation in international trade. The evidence in columns 1 and 4 suggest strong effects from the bilateral adoption of containerisation on manufactured goods trade equal to 60%. For total trade, which includes trade in major, minor and liquid bulk items such as iron ore, steel, grain and oil that cannot be containerised, the estimated effect is only 23%. In the two regressions, we included bilateral controls which are distance, common language, colonial relationship, border, along with the policy variables, FTAs, GATT membership and common currency.

The results from the remaining columns of table 5.5 indicate that other relevant bilateral factors may be omitted that are correlated with the likelihood that two countries adopt the container as a technology. In columns 2 and 5 we introduce country-pair FE alongside the country-time dummies. These additional FE control for all time invariant country-pair determinants of bilateral trade that were not already captured by the distance, shared borders, common language, and colonial history variables in regressions 1 and 4. Therefore, in columns 2 and 5, the effects of containerisation are identified from the variation within a bilateral pair across time and removing any increases or decreases to trade common to all trade flows for each origin or destination country. We find that the effects of containerisation are not statistically significant for total trade, but remain significant for manufactured goods. The magnitude of the effect of the introduction of containerisation at both the origin and destination ports for manufacturing trade is now at 10%.

In regressions 3 and 6, we consider the robustness of our results to differencing the data across 5-year periods. In first-differencing the data we control for the possibility that the ij FE are not time invariant but rather change over time. We find slightly stronger effects from containerisation in these regressions. In regression 3, the effect of containerisation on total trade is positive but still insignificant while in regression 6 the estimated effect on manufactured goods trade is 11%.

Our results in the above table indicate a consistent effect of containerisation on manufactured trade of around 10% or 11%. How does this compare to the policy variables that we include in the regression? We include three sets of policy variables as mentioned and described above.

In line with the literature, our results indicate some sensitivity to the inclusion of bilateral and country-time effects for these variables, most noticeably for the GATT variable. We find that the estimated effects of trade policy are generally larger than those for containerisation, between 3 and 5 times as large, and larger for total goods trade compared to manufacturing trade. The FTA coefficient of 0.41 in regression 2 is similar to the estimate found by Head et al. (2010) and only slightly smaller than the Baier and Bergstrand (2007) estimate of 0.46 when using country-pair and country-time effects and total trade. In percentages, the effect of FTAs on total trade is 50% and on manufactured trade 39%. No effect is found for GATT membership on total trade or manufacturing trade. This is contrary to the effect found in Head et al. (2010). The effects of having a common currency are even larger than FTA effects: 50% for manufactured goods and 69% for total goods trade. This is much lower than the effect found in Rose (2000) but higher than the effect for common currency found in Head et al. (2010).

5.7.4 Robustness Checks

In the previous section, we checked for the robustness of some of the results by considering an alternative model (first differenced model). We argue that the first differenced model is more convenient from an estimation point of view since it takes care of the ij-variables (distance, language, etc) but it is also the less restrictive model in the sense

Table 5.5: Effects of Bilateral Containerisation, Introducing it and jt dummies, 5-year interval periods, Two Specifications

Dep.Var: ln trade(ij)	Total Trade			Manufacturing		
	(1) FE Model	(2) FE Model	(3) 1st Diff (by ij)	(4) FEl Model	(5) FE Model	(6) 1st Diff (by ij)
port Cont(ij)	0.204***	-0.044	0.035	0.470***	0.103**	0.110**
	(0.0500)	(0.0463)	(0.0425)	(0.0528)	(0.0497)	(0.0466)
FTA	-0.155***	0.408***	0.161*	0.404***	0.327***	0.220**
	(0.0572)	(0.0686)	(0.0940)	(0.0555)	(0.0668)	(0.0892)
Both GATT	0.111***	-0.026	0.048	0.402***	0.020	0.024
	(0.0346)	(0.0454)	(0.0527)	(0.0387)	(0.0516)	(0.0599)
Com Cur	1.127***	0.526***	0.303***	1.331***	0.406***	0.210*
	(0.0660)	(0.0944)	(0.1116)	(0.0707)	(0.1033)	(0.1250)
ln Dist	-1.113***			-1.196***		
	(0.0119)			(0.0125)		
Border	0.311***			0.255***		
	(0.0496)			(0.0488)		
Common Language	0.536***			0.760***		
	(0.0233)			(0,0251)		
Colony	1.369***			1.083***		
	((0.0470)			(0.0451)		
Countries	157	157	157	157	157	157
Observations	68508	68508	49615	50413	50413	35415
R^2	0.234	0.540	0.168	0.3184	0.642	0.238
Dummies	it,jt	it,jt,ij	it,jt	it,jt	it,jt,ij	it,jt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

that it allows for ij FE to vary over time. In this section, we consider more robustness checks.

The effects of containerisation are identified in the above regression when a pair of countries containerise in different time periods. For some country-pairs the number of years between partial and full containerisation is short, whereas for others it can be spread many years apart. As an example, our containerisation dummy would be switched on for US trade with Myanmar only in 1983, even though the US has developed experience with containerisation since the 1950s. To test whether partial containerisation has an effect on trade, conditional on the effects of bilateral containerisation, we add to the regression an interaction between the containerisation dummy and a count of the number of years between partial and bilateral containerisation for that pair of countries.

The results from this regression, regression 1 in table 5.6, indicate that that this gap does not matter. The coefficient on the years of partial containerisation is negligible and statistically insignificant, while the direct effect is now slightly bigger but less significant. In regression 2, we add in a square of the interaction term between the container and the number of years of partial containerisation to allow for a non-linear relationship. In regression 3, we add in the square root of the same interaction term to allow a different type of non-linearity. Both regressions 2 and 3 confirm the same thing as regression 1 - that partial containerisation does not matter in this specification. In both regressions, the coefficient of the container variable is now poorly identified.

In regression 4 we use 1962, 1965, 1970, 1975, 1980, 1985 and 1990 as time points in the data set. As figure 4.5 in the previous chapter makes clear, the containerisation of countries is not evenly distributed across years, but rather tends to be clustered in specific time periods. Given what we assume about the speed with which containerisation is adopted in each country this may suggest that our results may be sensitive to the choice of years that we include in the regression. In regression 4 the estimated effect of containerisation on manufactured goods trade is 11% which is only slightly higher than the effect found in regression 5 table 5.5. However, the result is lower in the first-differenced model. Compared to table 5.5 column 6, in column 5 table 5.6, the coefficient of the container variable is positive but insignificant.

In columns 6 and 7, we choose the same time points as in regressions 4 and 5 but choose bilateral aggregate trade outcomes. Compared to table 5.5, the estimated effects of the container on total trade are not robust to the choice of time points. In column 6, the effect picked up on total trade is negative and significant at the 1% significance level. In the first-differenced regression (column 7), the coefficient of the container variable is negative but insignificant.

Table 5.6: Effects of Bilateral Containerisation - Robustness Checks

Dep. Var: ln trade(ij)	(1) Manuf	(2) Manuf	(3) Manuf	(4) Manuf	(5) Manuf (1st Diff)	(6) Total Trade	(7) Total Trade (1st Diff)
port Cont(ij)	0.115*	0.086	0.086	0.108**	0.067	-0.127***	-0.065
	(0.0603)	(0.0651)	(0.0687)	(0.0470)	(0.0429)	(0.0434)	(0.0403)
port cont(ij)*Yrs of part cont	-0.001	0.012					
	(0.0045)	(0.0125)					
port cont(ij)*Sq Yrs of part cont		-0.001					
		(0.0009)					
port cont(ij)*Sqrt Yrs of part cont			0.006				
			(0.0180)				
FTA	0.325***	0.326***	0.330***	0.256***	0.136	0.388***	0.246**
	(0.0672)	(0.0672)	(0.0672)	(0.0706)	(0.0907)	(0.0729)	(0.0954)
Both GATT	0.020	0.022	0.018	0.077	0.031	-0.029	0.035
	(0.0517)	(0.0517)	(0.0516)	(0.0494)	(0.0573)	(0.0437)	(0.0507)
Com Cur	0.407***	0.407***	0.407***	0.260***	-0.066	0.390***	0.074
	(0.1033)	(0.1033)	(0.1033)	(0.0881)	(0.1134)	(0.0802)	(0.1035)
Countries	157	157	157	157	157	157	157
Observations	50413	50413	50413	50340	34972	69398	50270
R^2	0.642	0.642	0.642	0.641	0.254	0.535	0.172
Dummies	it,jt,ij	it,jt,ij	it,jt,ij	it,jt,ij	it,jt	it,jt,ij	it,jt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.7.5 Introducing Railway Containerisation

We now return to the information we have on railway containerisation that we introduced earlier and incorporate them into our model. We merge railway and port containerisation as we did in regression 5 table 5.4. In other words, we allow for intermodality in transport between ships and railway. Recognising that containerisation encompasses transportation by sea as well as rail, we use the data to define a second containerisation variable which we call full containerisation which switches to 1 if i and j have both containerised ports or railways at time t. Our container variables become as follows:

$$PortCont_{ijt} = \begin{cases} 1, & \text{i and j have both containerised ports at time t} \\ 0, & \text{otherwise} \end{cases}$$

$$FullCont_{ijt} = \begin{cases} 1, & \text{i and j have both containerised ports or railways at time t} \\ 0, & \text{otherwise} \end{cases}$$

In table 5.7, we report results for the effect of containerisation on both total trade and manufactures. The top part reports the effects of full containerisation as defined above while the bottom part reports the effects of port containerisation and hence only restates the results of table 5.5. Similar to section 5.7.3, In the first 3 columns, we estimate 3 different (FE) specifications for the effects of containerisation on total trade. In columns 1 we estimate equation 5.2 with it and jt dummies and a host of country-pair time invariant controls. In column 2, we estimate the same equation but we add ij dummies to control for observable and non-observable country-pair variables. In column 3, we estimate a first-differenced model or equation 5.3 (with it and jt dummies). In columns 4-6, we repeat the same exercise on a sample restricted to manufactures only.

As for the results, when we allow for railway containerisation, we find that full containerisation reduces total trade by around 11% when we control for it and jt dummies. The coefficient is significant at the 5% significance level. In column 2, when we add in ij dummies, the coefficient of the full container variable doesn't change much and remains negative at about 12% but less significant at the 10% significance level. This compares to a positive effect of around 23% for port containerisation in the first column and no effect in the second column. In column 3, when we estimate a first-differenced model, the effect of full containerisation is positive but insignificant (0.065). This is slightly higher than the effect found for port containerisation although both coefficients are insignificant. There are no differences between the estimates of policy variable coefficients between the top and bottom parts of the table, between full and port containerisation regressions.

When we restrict our sample to manufactures only, the results differ substantially. Unlike the estimations for total trade, full containerisation returns stronger results on manufacturing trade than port containerisation alone. This is suggestive of the importance of rail containerisation on the trade in these products. The coefficient estimates of the full container variable are positive and significant in all three estimations. In column 4, the effects of full and port containerisation on manufactures are estimated to be around 60 and 68% respectively. When controlling for ij dummies as well as for country-year (it and jt) dummies in column 5, the effect of containerisation is significantly lower at 14% for full containerisation somewhat similar to the 11% estimated for port containerisation, the coefficient of the full container variable being significant at the 10% significance level. In the first differenced estimation in column 6, the estimated effect is around 22% for full containerisation compared to 12% for port containerisation. The higher coefficient estimates for the full container variable than the port container variable suggests that intermodal transport has additional effects on this trade. As for the other policy variables, entering a free trade agreement seems to have a positive and significant effect on manufacture trade in all three estimations. The effect is estimated to be around 48% when controlling for country-time dummies, 39% when we add country-pair dummies, and around 27% in the first difference estimation. These estimates are similar to what Baier and Bergstrand (2007) when estimating the same models for total trade. The effect of GATT membership on manufacture trade is less evident than the effect of FTAs. In column 4, the effect of GATT membership is similar to that of FTAs in that specification, around 48%. In columns 5 and 6, we find no evidence for any effect of GATT membership on manufacture trade. The coefficients are both very small and insignificant. Common currency seems to matter for the trade of manufactured goods. The effect is very large in column 4 in the magnitude of 278%, becomes smaller at around 50% in column 5, and positive but insignificant in column 6. The estimations for the policy variables are almost identical in the top and bottom tables. Comparing the policy and technology variables in the manufacturing trade regressions, the effects of the policy variables are 2 to 3 times the size of containerisation on manufacturing trade in the FE model but the effect of FTA is very close to the effect of the container in the first-differenced model.

To conclude this section, we consider the effects of full containerisation (ports and

Table 5.7: Effects of Full Containerisation (Railway and Ports), Total Trade and Manufactures, Two Specifications

	Dep.Var: ln trade(ijk)	Total Trade			Manufacturing		
		(1) FE Model	(2) FE Model	(3) 1st Diff (by ij)	(4) FE Model	(5) FE Model	(6) 1st Diff (by ij)
Port and Railway	Full Cont(ij)	-0.120**	-0.126*	0.065	0.516***	0.136*	0.193***
		(0.0554)	(0.0492)	(0.0429)	(0.0600)	(0.0553)	(0.0476)
	FTA	-0.153***	0.402***	0.166	0.395***	0.330***	0.234**
		(0.0572)	(0.0686)	(0.0941)	(0.0555)	(0.0668)	(0.0893)
	Both GATT	0.120***	-0.027	0.049	0.393***	0.018	0.027
		(0.0346)	(0.0453)	(0.0527)	(0.0388)	(0.0516)	(0.0599)
	Com Cur	1.128***	0.526***	0.303**	1.329***	0.408***	0.210
		(0.0660)	(0.0944)	(0.112)	(0.0707)	(0.1033)	(0.1250)
	ln Dist	-1.116***			-1.189***		
		(0.0119)			(0.0125)		
	Border	0.315***			0.256***		
		(0.0496)			(0.0488)		
	Common Language	0.539***			0.759***		
		(0.0233)			(0.0251)		
	Colony	1.367***			1.088***		
		((0.0470)			(0.0451)		
	Countries	157	157	157	157	157	157
	Observations	68508	68508	49615	50413	50413	35415
	R^2	0.7303	0.540	0.168	0.2142	0.642	0.238
	FE	it,jt	it,jt,ij	it,jt	it,jt	it,jt,ij	it,jt
Port Containerisation	Port Cont(ij)	0.204***	-0.044	0.035	0.470***	0.103**	0.110**
		(0.0500)	(0.0463)	(0.0425)	(0.0528)	(0.0497)	(0.0466)
	FTA	-0.155***	0.408***	0.161	0.404***	0.327***	0.220**
		(0.0572)	(0.0686)	(0.0940)	(0.0555)	(0.0668)	(0.0892)
	Both GATT	0.111***	-0.026	0.048	0.402***	0.020	0.024
		(0.0346)	(0.0454)	(0.0527)	(0.0387)	(0.0516)	(0.0599)
	Com Cur	1.127***	0.526***	0.303**	1.331***	0.406***	0.210*
		(0.0660)	(0.0944)	(0.112)	(0.0707)	(0.1033)	(0.1250)
	ln Dist	-1.113***			-1.196***		
		(0.0119)			(0.0125)		
	Border	0.311***			0.255***		
		(0.0496)			(0.0488)		
	Common Language	0.536***			0.760***		
		(0.0233)			(0,0251)		
	Colony	1.369***			1.083***		
		((0.0470)			(0.0451)		
	Countries	157	157	157	157	157	157
	Observations	68508	68508	49615	50413	50413	35415
	R^2	0.2398	0.540	0.168	0.3184	0.642	0.2382
	FE	it,jt	it,jt,ij	it,jt	it,jt	it,jt,ij	it,jt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

rail) on both total trade and manufacturing trade. We estimate a FE and first-differenced model to identify the effects of containerisation. We find mixed results for the effect of containerisation on aggregate trade flows. The FE model estimates a negative effect of around 12% of full containerisation with country-time and country-pair effects. We estimate a positive but statistically insignificant coefficient for the full container variable in the first-differenced model. On the other hand, we find economically positive and statistically significant effects of containerisation on manufactures trade. The effect on manufactured trade is estimated between 14% and 22%. The effects of FTAs are estimated to be slightly higher to 3 times the effects of containerisation on the same trade.

5.7.6 Hetrogeneity in the SITC 1-digit Industries

The estimations for manufacturing trade suggest that the effects of containerisation are not uniform across all products but rather that there is heterogeneity in the effects on the different industries. While we find mixed results for the effects of containerisation on total trade, we find evidence for a positive and significant effect on the aggregated manufactured goods. In this section, we look at the effects that containerisation had on the bilateral trade flows in the individual 1-digit industries. The dependent variable is the bilateral trade flow in the 1-digit SITC industries separately. We consider the effects of full containerisation in this analysis. Similar to the county aggregate trade flows regressions, we estimate both a FE as well as a first-differenced model.

The results in table 8 paint a mixed picture. Although we get a negative effect of containerisation on total trade in the FE regression, we only get a negative and significant effect in the same regression on category 5 goods or "Chemicals and related products". It can be argued that most goods in this category are not moved in containers. Nevertheless, containerisation has a negative effect of around 13% on the trade in products of category 5. The coefficient of the containerisation variable is significant at the 5% significance level. The coefficient of the container variable becomes negligible and insignificant in the first difference estimation of the category 5 regression.

Of all industries, containerisation had a strong and positive effect in both specifications on industry 8 or "Miscellaneous Manufactured Articles". The products in this category are perhaps most suitable for containerisation. Some of the products under this category include handbags, apparel and clothing, footwear, toys and some consumer electronics. In the FE regression, containerisation leads to an increase of around 40% in the trade of category 8 goods. The first difference regression estimates an effect of 32% on the trade in category 8 goods. Also, we capture an positive and significant effect of containerisation on the trade in category 7 goods or "Machinery and Transport". This category includes industrial machinery as well as other consumer electronics such as TV sets and computers. In the FE regression, we estimate an effect of around 30% on the trade in this category. The first difference regression estimates an effect of the container which almost half in magnitude, around 14% and the coefficient is significant at the 10% significance level. As for the other main manufacturing category, industry 6 which is "Manufactured goods classified chiefly by material", we only find a positive and significant effect of around 16% for the container on these products when we estimate a first difference regression. The FE regression picks up an effect which is half that of the first difference regression but the coefficient of the container variable is insignificant.

The other 1-digit product categories where we see a positive and significant effect in at least one of the two specifications are categories 0 and 3, or "Food and Live Animals" and "Mineral Fuels, lubricants". In the FE regression in category 3, the coefficient of the container variable is positive but insignificant (0.208). In the first difference regression however, the coefficient is positive, significant, and quite large and suggests an effect of around 50% on the trade in the category. This is quite surprising because this suggests that the use of the container affected products that are non-containerisable in nature such as oil and fuels. In category 0 regressions, the evidence for the effect of the container is less clear cut in magnitude and significance. The effect captured in the FE regression is positive but insignificant whereas the effect of the container on the trade in the products of that category in the first difference is around 14% and the coefficient is significant at the 10% significance level.

As for the remaining product categories, which are category 1 ("Beverage and Tobacco"), category 2 (Crude Materials except fuels), category 4 (Animal and vegetable oils), and category 9 (Commodities and transactions not elsewhere classified), we find no evidence for any effect of containerisation in any of the regressions. The coefficients of the container variables in each of their regressions are very small and insignificant.

In summary, we find that the effects of containerisation are heterogeneous when the

Table 5.8: Effects of Full Containerisation on Trade at the 1-digit level (SITC)

	Total Trade		SITC 0 Food and Live Animals		SITC 1 Beverage and Tobacco	
Dep. Var: ln trade(ij)	FE Model	1st Diff	FE Model	1st Diff	FE Model	1st Diff
Full Cont(ij)	-0.126**	0.065	0.076	0.130*	0.0358	0.0238
	(0.0492)	(0.0429)	(0.0645)	(0.0570)	(0.0974)	(0.0836)
FTA	0.402***	0.166*	0.104	0.061	0.474***	0.239*
	(0.0686)	(0.0941)	(0.0741)	(0.101)	(0.0822)	(0.1062)
Both GATT	-0.027	0.049	0.138*	-0.021	0.144	-0.0141
	(0.0453)	(0.0527)	(0.0618)	(0.0741)	(0.0978)	(0.1122)
Com Cur	0.526***	0.303***	0.307**	0.105	0.534***	0.377*
	(0.0944)	(0.1116)	(0.111)	(0.540)	(0.1332)	(0.1572)
Countries	157	157	157	157	157	157
Observations	68508	49615	45439	31398	21890	14271
R^2	0.0123	0.1677	0.511	0.186	0.594	0.2833
FE	it,jt,ij	it,jt	it,jt,ij	it,jt	it,jt,ij	it,jt
	SITC 2 Crude Materials except fuels		SITC 3 Mineral Fuels, lubricants		SITC 4 Animal and vegetable oils	
Full Cont(ij)	-0.035	.074	0.208	0.406***	-0.044	0.023
	(0.0682)	(0.0593)	(0.1378)	(0.1268)	(0.1486)	(0.1315)
FTA	0.179**	0.004	0.304**	0.345**	0.412***	0.577***
	(0.0744)	(0.1007)	(0.1196)	(0.1631)	(0.1140)	(0.1576)
Both GATT	-0.106	-0.006	0.105	0.464***	-0.309**	-0.385**
	(0.0653)	(0.0774)	(0.1335)	(0.1668)	(0.1463)	(0.1798)
Com Cur	0.298**	0.287**	0.574**	0.088	0.962***	0.299
	(0.1199)	(0.1435)	(0.2299)	(0.2855)	(0.2072)	(0.2507)
Countries	157	157	157	157	157	157
Observations	39601	27180	19123	12053	15430	9732
R^2	0.0179	0.2009	0.0013	0.2790	0.1090	0.2671
FE	it,jt,ij	it,jt	it,jt,ij	it,jt	it,jt,ij	it,jt
	SITC 5 Chemicals and related products		SITC 6 Manufactured Goods by Material		SITC 7 Machinery and Transport	
Full Cont(ij)	-0.134**	-0.023	0.070	0.147***	0.264***	0.127*
	(0.0680)	(0.0602)	(0.0607)	(0.0527)	(0.0714)	(0.0653)
FTA	0.265***	0.071	0.399***	0.267***	-0.028	0.184*
	(0.0680)	(0.0922)	(0.0693)	(0.0927)	(0.0725)	(0.1006)
Both GATT	-0.136**	-0.214***	-0.015	-0.001	0.169***	0.023
	(0.0614)	(0.0724)	(0.0569)	(0.0661)	(0.0655)	(0.0813)
Com Cur	0.438***	0.273**	0.465***	0.210	0.486***	0.208
	(0.1146)	(0.1382)	(0.1115)	(0.1339)	(0.1197)	(0.1530)
Countries	157	157	157	157	157	157
Observations	35790	24790	45374	31664	38849	26783
R^2	0.0055	0.2293	0.0191	0.2446	0.694	0.2630
FE	it,jt,ij	it,jt	it,jt,ij	it,jt	it,jt,ij	it,jt
	SITC 8 Miscellaneous Manufactured Articles		SITC 9 Commodities and transactions NEC			
Full Cont(ij)	0.332***	0.277***	0.126	0.062		
	(0.0566)	(0.0488)	(0.1266)	(0.1193)		
FTA	0.066	0.053	0.184	0.239		
	(0.0617)	(0.0818)	(0.1127)	(0.1688)		
Both GATT	-0.052	-0.017	0.051	0.247		
	(0.0534)	(0.0625)	(0.1155)	(0.1498)		
Com Cur	0.266***	0.059	0.573***	0.042		
	(0.1002)	(0.1229)	(0.1624)	(0.2118)		
Countries	157	157	157	157		
Observations	40279	27740	21259	12404		
R^2	0.0292	0.2963	0.0247	0.3894		
FE	it,jt,ij	it,jt	it,jt,ij	it,jt		

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

sample is restricted to trade flows in each of the ten 1-digit SITC industries separately. We find that containerisation had the strongest effects on industries 8 (Miscellaneous Manufactured Articles), and industry 7 (Machinery and transport equipment). We estimate an effect of the container on the trade in industry 8 of between 32% and 40% and between 14 and 30% on trade in industry 7. We find some or no evidence for container effects on the other industries.

5.8 A Discussion on Missing Trade Values

In practice, many potential bilateral trade flows are not active. The data in front of us records either positive value or missing observations. The data may record a missing observation that is truly missing or it may reflect shipments that fall below a threshold above zero. Also, there may be observations that are in fact zeros.

Missing/zero observations might be a problem if they have economic meaning. For example, Helpman et al. (2008) argue that zeros are due to fixed costs of export facing monopolistic competitive firms. OLS estimations that ignore missing/zero observation may be biased because of selection bias.

In our case, missing observations may potentially affect our results for the container if containerisation is a determinant of non-zero trade values which is likely. It is however not clear whether any such bias will be upwards or downwards and there is no evidence for the direction of the bias.

The NBER-UN data set covers international trade flows for the period 1962-2000. The period 1962-1983 covers most countries in the world. The panel data set is unbalanced for this period and many observations are missing. For the period 1984-1990, the data set only reports trade for 63 countries[11]. This means that only bilateral trade flows where at least one of the 63 countries is a party are available. In other words, only trade flows of the 63 countries with the rest of the world and among each other are included. Here too, the panel data set is unbalanced.

The data set reports trade as small as 1000 USD for the period 1962-1983 and the minimum trade value reported is 100,000 USD between 1984-1990 (There are very few observations with values less than 100,000 USD).

Given 157 countries in our sample and 7 time points, we have 157*156*7 or 171,444

[11]The list of these countries is provided in table A.5 in the appendix.

potential trade relations. We plot the distribution of trade flow values in the data set. In figure 4.1, we find that approximately 50% of potential trade observations are missing, around 20% are less than $100,000, around 15% are between $100,000 and $1 million, around 10% are between $1 million and $10 million, and around 5% are higher than $10m in value.

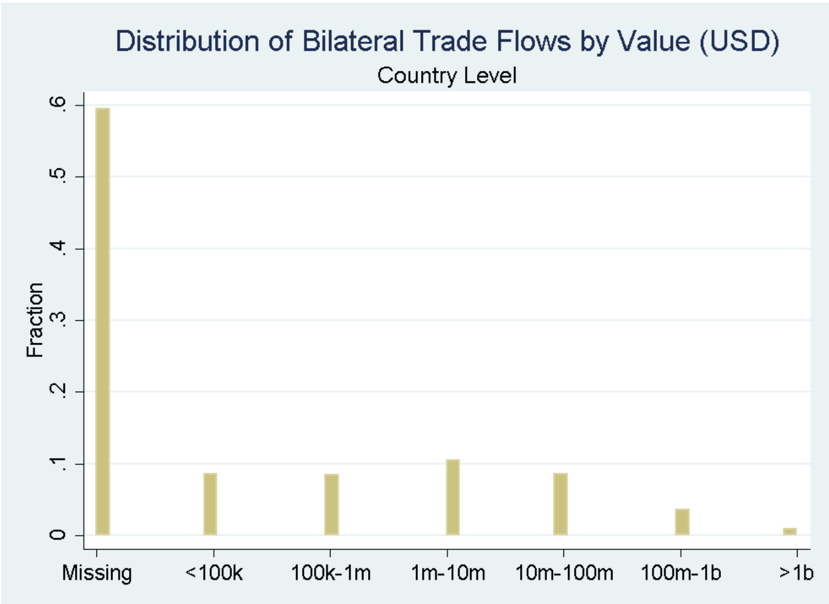

Figure 5.1: Distribution of Trade Observations by values at the country level

When we check the numbers of missing observations per country, we find a clear correlation between the level of development of a country and missing trade. In the appendix B, we list all 157 countries in our data set and their respective missing trade observations (both exports and imports). In the 29 years between 1962 and 1990, the UK has the least number of missing observations, followed by Japan, and then Italy, and so on. St. Helena has the largest number of missing observation. The most developed countries have the least missing observations. This is confirmed in figure 4.2 where we plot the distribution of trade flows by value for North-North trade. Recall that we defined North countries as OECD countries minus Turkey in the previous chapter[12]. We find that we have almost no missing observations or any observations with values less than $100,000 in North-North trade. Only around 2% of the observations is between $100,000 and $1 million in value. Most of the observations are higher than $1 million in

[12]While Turkey is a founding member of the OECD, Turkey is a late containeriser. Twenty two countries are classified as North in our sample. These are: Australia, Austria, Belgium, Canada, Denmark, Finland, Fm German FR, France, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and USA

value. Namely, 10% of all North-North trade observations are between $1 million and $10 million, close to 30% is between $10 million and $100 million, over 35% is between $100 million and $1 billion, and just under 25% is higher than $1 billion in value.

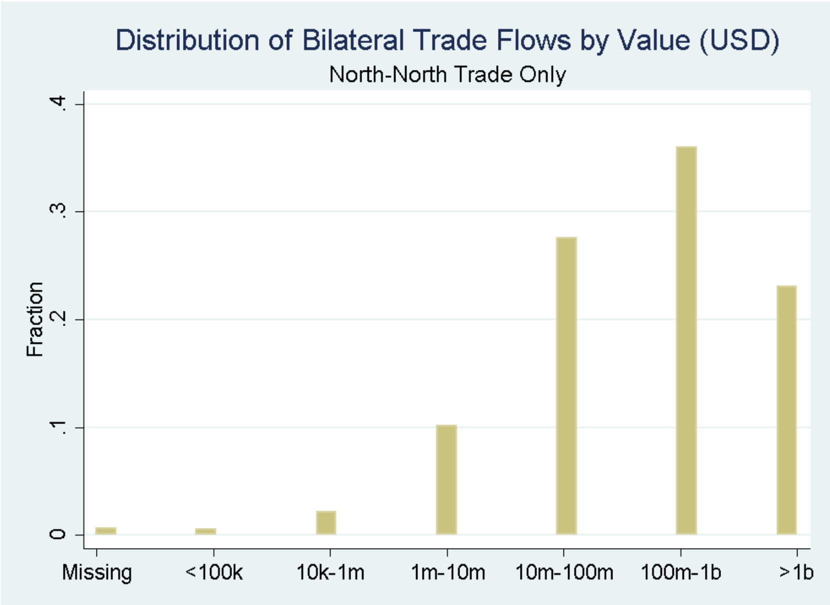

Figure 5.2: Distribution of Trade Observations by values at the country level - North North Trade

We also plot the distribution of trade flow values in North South trade. The first thing we notice is that substantially less observations as percentage of total observations are missing compared to the entire sample. Only around 17% of all North South trade observations are missing. Of the positive values, 10% of all observations is less than $100,000 in value, around 15% is between $100,000 and $1 million, just below 25% is between $1 million and $10 million, a similar percentage is between $10 million and $100 million, around 10% is between $100 million and $1 billion, and only around 2% is above $1 billion in value.

There is no consensus in the literature on how to deal with missing observations and zeros. Most studies have tended to ignore zeros especially when estimating gravity equations. CES/Armington preferences and demand functions that the gravity equation is based on as well the model of Eaton and Kortum (2002) do not allow for zeros/missing observations. In these models, some volume will be purchased no matter how high the price[13]. This makes those estimations conditional on positive trade flows.

[13]More recently, Novy (2010) derives a gravity equation from a translog expenditure function which allows for zeros in demand.

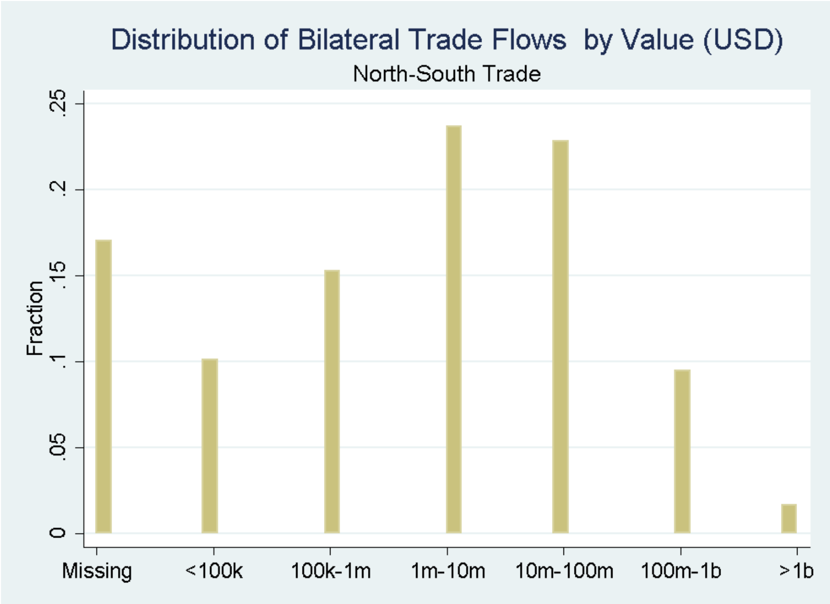

Figure 5.3: Distribution of Trade Observations by values at the country level - North South Trade

Silva and Tenreyro (2006) suggest estimating trade flows with a Poisson Pseudo-Maximum Likelihood (PPML) estimator because it allows for zeros although the main reason for proposing PPML is to deal with heteroskedastic errors. The solution of Santos-Silva has not convinced all researchers though. Martin and Pham (2008) argue that Tobit estimators outperform PPML when zeros are present and heteroskedasticity can be controlled for by using size-adjusted trade as the dependent variable.

The issue of zeros and missing trade requires a proper deeper analysis and that is an avenue for future research. Besides, in our data, we do not know for sure what is zero and what is missing as highlighted by the authors of the data set (Feenstra et al. (2005)). Therefore, applying 'off the shelf' solutions would provide a false impression that the problem has been dealt with. Also the difference-in-difference approach that we employ here, which our regressions resemble, does not handle missing observations. Having said that, our work is not therefore a description of the full effects of containerisation on world trade but rather considers the effects on non-zero trade flows.

One way we could choose to deal with this is by restricting our data set to samples in which the missing observations is less of an issue. For instance, based on the above, we might want to study the effects of containerisation on North-North trade or North-South trade separately. There may be other reasons why we want to concentrate on

North-North trade. Recall that our containerisation measure is partial in the sense that it only captures ports and rail. This may contain errors as a result. Those errors are likely to be minimised for North countries from what learn from the narrative. This is because North countries were first to containerise and containerisation happened more or less concurrently in all modes of transport in these countries.

5.9 Empirical results

We estimate equations 5.2 and 5.3 to identify the effects of full containerisation in the subsamples that we discussed above. We start however, by balancing our data set.

In table 5.8 columns 1 and 2, we consider a balanced sample only. Compared to the entire sample (table 5.7), we capture no effect for containerisation on total trade in the FE model (column 1). In the first-differenced model on the other hand, we estimate a strong positive and significant coefficient for the container variable. The effect is estimated around 24% and the coefficient is significant at the 1% significance level. This is suggestive of a strong effect of containerisation on the intensive margin of trade[14]. Containerisation and its effects on the intensive and extensive margins of trade is not dealt with in this thesis but will be the subject of future research.

In the remaining results in table 5.8, we restrict our data set to samples where missing observations is less of a problem. In columns 3 and 4, we restrict our sample to North North trade. We find no effect of containerisation on North-North trade from the two estimations. The container coefficient estimate is negative but insignificant in column 3 and negligible in column 4. Similarly, we find no effect for full containerisation on North-South trade in columns 5 and 6. The container coefficients are now positive but insignificant in the estimations. And finally, for the sake of completion, we run the same regressions on a sample restricted to South South trade. Here too, we don't pick up any effects for containerisation on South South trade in columns 7 and 8.

As for the other controls, compared to the entire sample regressions in table 5.7, we estimate larger effects of FTAs on trade in the balanced sample. The effect of FTA on trade is around 55% in the FE model, and 24% in the first-differenced model. The

[14]Felbermayr and Kohler (2006): "World trade evolves at two margins. Where a bilateral trading relationship already exists it may increase through time (intensive margin). But trade may also increase if a trading bilateral relationship is newly established between countries that have not traded with each other in the past (extensive margin).

coefficients are negative but insignificant for GATT membership which is somehow a similar finding to table 5.7. Also, the effects of common currency are larger in the balanced sample. As for North North trade regressions, we still pick up a strong and significant effect for FTAs on bilateral trade flows. The effect is similar in the FE model and the first-differenced model (27%). As for GATT memberships, we estimate larger effects on trade in North North trade compared to the entire sample. This effect is strong and significant in the FE model at around 37% and the coefficient is significant at the 10% significance level. This effect is poorly identified in the first-differenced model. Also, we pick up stronger effects for common currency on North-North trade and the coefficients are both significant.

As for North-South trade, we find no evidence of any effect for FTAs on this trade. We find some evidence that GATT membership negatively affects this trade. This effect is around negative 20% in the FE model and the coefficient is significant at the 10% significance level. Common currency has a positive effect on North-South trade. This effect is quite large in the FE model and the estimated coefficient suggests an effect of around 81% on this trade and it is significant at the 1% significance level. The coefficient of the common currency variable is positive but insignificant in the first-differenced model.

Finally, in the South South regressions, we find no evidence for an effect of FTA and GATT membership on this trade. There is evidence for an effect of common currency on South-South trade, The coefficients of the common currency are positive, strong, and significant at the 10% significance level in both estimations. The estimates of the effects are around 46% and 64% respectively.

Table 5.9: Effect of Full Containerisation of Total Trade - Dealing with Missing Trade

Dep.Var: ln trade(ijk)	Balanced Sample		North-North Trade		North-South Trade		South-South Trade	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FE Model	1st Diff	FE Model	1st Diff	FE Model	1st Diff	FE Model	1st Diff
Full Cont(ij)	0.000	0.215***	-0.237	-0.018	0.288	0.0419	-0.146	-0.003
	(0.0661)	(0.0526)	(0.138)	(0.0935)	(0.233)	(0.185)	(0.0915)	(0.0826)
FTA	0.438***	0.232**	0.246***	0.249***	-0.000	0.046	0.480	0.343
	(0.0609)	(0.0836)	(0.0373)	(0.0412)	(0.170)	(0.231)	(0.262)	(0.300)
Both GATT	-0.064	-0.035	0.313*	0.174	-0.227*	-0.198	-0.080	0.062
	(0.0506)	(0.0577)	(0.138)	(0.133)	(0.109)	(0.120)	(0.0723)	(0.0855)
Com Cur	0.807***	0.396**	0.773***	0.439*	0.595***	0.226	0.377*	0.494*
	(0.100)	(0.1210)	(0.156)	(0.172)	(0.112)	(0.137)	(0.176)	(0.208)
Countries	157	157	22	22	157	157	135	135
Observations	34713	29754	3215	2753	33838	27462	31455	19400
R^2	0.691	0.253	0.935	0.367	0.633	0.2649	0.501	0.176
FE	it,jt,ij	it,jt	it,jt,ij	it,jt	it,jt,ij	it,jt	it,jt,ij	it,jt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In table 5.9, we estimate the same regressions for manufacturing trade as in table

5.8. In columns 1 and 2, we consider a balanced panel. The container variable here measures full containerisation as well. The coefficient of the full container variable is positive but insignificant in column 1 for the FE model estimation. In column 2, for the first-differenced estimation, we find a strong positive and significant effect for full containerisation on manufactures trade. Containerisation leads to an increase of around 28% in manufactures trade. This result suggests that containerisation has a strong positive effect on the intensive margin of trade when considering bilateral manufactures trade.

When restricting the sample to North-North trade only in columns 3 and 4, we find no evidence for an effect of containerisation on manufacturing trade. In column 3, the FE model estimates a negative but insignificant coefficient of the container variable. Similarly, in column 4, we estimate a negative and statistically insignificant coefficient of the container variable albeit much smaller in absolute value than column 3.

In columns 5 and 6, we consider North-South trade. We estimate large positive but statistically insignificant coefficients for the container variable in both the FE and first-differenced models.

In the last two columns, we restrict our sample to South-South trade and estimate the same models. In the FE model, we estimate a positive coefficient for the container variable but the effect is not well-identified. The first-differenced model however estimates a positive and strong effect of 'full' containerisation on South-South manufacturing trade of around 22%, the coefficient being significant at the 10% significance level.

As for the policy variables in question, we find evidence that signing a free trade agreement has a positive and significant effect on manufactures trade in the balanced panel estimation in columns 1 and 2. This effect is around 27% and the coefficient of the FTA variable is significant at the 1% significance level in the FE model. In the first-differenced model, the effect is around 18% and the significance level is at the 10% level. Similarly, we find a positive and significant effect for FTA in the North-North trade regressions in columns 3 and 4. The effect is around 41% and 28% respectively and the coefficients are significant at the 1% significance level. In columns 5 and 6 which correspond to North-South trade, we find no evidence for such an effect. The coefficients are positive but insignificant. In the last two columns, we find mixed results of FTAs on manufactures trade. In the FE model, the effect is very strong around 136% and the coefficient is significant at the 1% significance level. In the first-differenced estimation, this effect is insignificant.

As for GATT membership, we find no evidence of an effect on manufactures trade in all estimations except one. The effect is positive and significant on North-South trade in the FE model. The estimate is around 30% and the coefficient is significant at the 10% significance level.

Finally, common currency seems to matter in North-North manufactures trade. The estimates thereof are both very strong and significant. The effects are estimated to be around 189% in the FE model and 86% in the first-differenced model. When we estimate a balanced panel in columns 1 and 2, we find common currency to have a strong and significant effect on manufactures trade in the FE model but not in the first-differenced model. The effect in column 1 is around 87%. Similarly, in the North-South trade estimations, we find a positive and significant effect for adopting a common currency on manufactures trade in column 5 but not column 6. The coefficient estimate in column 5 is around 52%. In columns 7 and 8, we find no evidence for an effect in South-South manufacturing trade.

Table 5.10: Effect of Full Containerisation of Manufacturing Trade- Dealing with Missing Trade

Dep.Var: ln trade(ijk)	Balanced Sample		North-North Trade		North-South Trade		South-South Trade	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FE Model	1st Diff	FE Model	1st Diff	FE Model	1st Diff	FE Model	1st Diff
Full Cont(ij)	0.112	0.247***	-0.206	-0.014	0.496	0.168	0.177	0.195*
	(0.0787)	(0.0605)	(0.167)	(0.124)	(0.285)	(0.233)	(0.108)	(0.0955)
FTA	0.241***	0.179*	0.344***	0.256***	0.218	0.326	0.860**	0.419
	(0.0606)	(0.0792)	(0.0453)	(0.0551)	(0.184)	(0.249)	(0.274)	(0.310)
Both GATT	-0.056	-0.041	0.022	0.195	0.260*	0.183	-0.073	0.000
	(0.0593)	(0.0661)	(0.181)	(0.1900)	(0.130)	(0.148)	(0.0856)	(0.0993)
Com Cur	0.625***	0.102	1.059***	0.621**	0.421***	0.159	0.237	0.183
	(0.111)	(0.130)	(0.190)	(0.229)	(0.122)	(0.152)	(0.225)	(0.270)
Countries	157	157	22	22	157	157	135	135
Observations	22883	19614	3178	2715	27440	21172	19795	11528
R^2	0.785	0.368	0.924	0.3874	0.706	0.325	0.614	0.273
FE	it,jt,ij	it,jt	it,jt,ij	it,jt	it,jt,ij	it,jt	it,jt,ij	it,jt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In conclusion, restricting the investigation to subsamples where missing observations are less a concern yield mixed results. Balancing the panel suggests that (full) containerisation has had strong and positive effects on aggregate trade and manufacturing trade of around 24% and 28% respectively if one considers the first-differenced model. Compare this to the negative container coefficient estimated in the FE model and the positive but insignificant coefficient in the first-differenced model in table 5.7 for total trade.

We also conclude that containerisation did not have any significant effects on North-North, North-South, or South-South aggregate trade separately. There is some evidence that containerisation has a positive effect of around 22% on South-South trade when estimating a first-differenced model.

The results may be strongest for North-South and South-South but those are parts of the dataset where we have least confidence both in terms of the trade data (missing/zeros) and the container variable. This may suggest that a causal effect from containerisation in trade flows is difficult to establish using the aggregate trade flows and specifications in this chapter.

5.10 Chapter Conclusion

In this chapter, we consider different specifications to identify the effects of containerisation on bilateral aggregate trade outcomes. The purpose of this chapter is to provide an initial exploration into how containerisation should be modelled in this context. We consider annual data, 5-year intervals, port containerisation, port and rail containerisation, and several robustness checks. We also address some econometric problems that are likely to feature in the estimations such as omitted variable bias and endogeneity.

In order to identify the effects of containerisation from other determinants of trade, we start our investigation from the gravity framework. We initially use annual data. Containerisation is measured as a country-year variable in these estimations. Estimating a FE model in which we control for country-pair FE yields an effect for port containerisation of around 22% on aggregate trade flows when both the origin and destination countries adopt the technology in ports in addition to an annual growth rate of around 3% (trend). This result is robust to including policy variables and to the exclusion of top trading partners for each country. The result is not homogenous across country groups. The first gravity estimations suggest that containerisation affected trade of low-income countries the most followed by OECD-countries - 41% and 30% respectively. Containerisation has led an island country to increase its exports by twice as much as a non-island economy. Landlocked countries seem to have benefitted from their neighbour port's adoption of containerisation.

We also estimate an additional effect for containerisation by rail on the aggregate trade flows. When allowing intermodal transport by merging the port and rail container - we call this full containerisation, the effect of 'full' containerisation on total trade is estimated to be around 30% when both the origin and destination countries adopt the container and hence higher than the estimated effect of port containerisation in the benchmark gravity estimations.

The derivation of a structural gravity equation from microeconomic foundations showed that estimations of the 'traditional' gravity equation suffer from omitted variable bias. This is because these estimations have long ignored 'multilateral resistances'. In line with the literature, we control for multilateral resistances using FE - importer and exporter-time FE in our setting. To be able to include the country-time dummies, we need to measure containerisation as a bilateral adoption of the technology. We also choose a pooled panel at 5-year intervals. We propose two specifications to estimate the effects of containerisation on trade flows: a FE model based on the gravity equation and a first-differenced model. We argue that the first-differenced model is the least restrictive one.

Controlling for multilateral resistances wipes out the port container effect on aggregate trade flows. We find however that bilateral port containerisation has a positive and significant effect on manufacturing trade or around 11%. We define manufacturing in our data set to be industries 6 and 8 at the 1-digit SITC product level. By merging port and railway container data to allow for intermodal transport, we find that full containerisation had a negative or no effect on total trade. We find however that full containerisation had a strong positive effect on the trade in manufactures of between 14% and 22%. We also find a strong positive effect of containerisation on both total and manufactures trade of 24% and 28% when considering a balanced panel and estimating the first-differenced model.

The container measure that we have constructed is partial in the sense that it only captures ports and rail. It does not capture the third mode of transport which is roads. Error may also be present in the data from the source (we have only one source for our data and we cannot cross-check this data for each country). The narrative suggests that those errors are likely to be minimised for North countries. This is because North countries were first to adopt the technology and our measure is likely to capture containerisation in all modes of transport. Also, we find that missing/zero trade flows are least present in trade flows of North countries.

We therefore concentrate our analysis on North-North trade and investigate the effects of containerisation on North-South and South-South trade as well. We find however no effect for containerisation on North-North when we consider total trade and manufacturing trade. We find stronger results when considering subsamples of North-North and North-South trade but these are parts of the dataset where we have least confidence both in terms of the trade data and the container variable.

The analysis in this chapter may suggest that a causal effect from containerisation on trade flows is difficult to establish using the approach in this chapter. This might be because there are differences in the containerisability of products and our trade data may be dominated by products that are not containerisable. Also, the different estimates of the effects of containerisation on total trade and manufacturing trade suggest that containerisation affected different products differently. Anderson (2011) suggests that aggregation bias may be present in models that predict bilateral trade flows because of sectorially varying trade costs and sectorially varying elasticities of trade with respect to costs. We therefore deal with containerisability of products in the next chapter. Another possibility for the results in this chapter is that the effects of containerisation take longer than 5-years to materialise. We investigate this in chapter 7.

Chapter 6

Estimating the Effects of Containerisation on International Trade at the Product Level

6.1 Introduction

We assumed in the previous chapter that all goods were containerisable. If this is not the case, then this may help to explain the weaker evidence towards the end of the previous chapter. However the solution is not just simply to create a containerisable and non-containerisable definition. Take cars for instance. While cars cannot be containerised, car parts and their intermediate inputs can. This suggests that while cars are not moved in containers, trade in cars may be affected by the container. We see this clearly in table 4.5 (chapter 4) where parts of cars and motor vehicles become the top traded containerisable commodity in 1990 after containerisation was adopted worldwide. The car example demonstrates that the issue is not as simple as that: non-containerisable products may be affected by containerisation. This means that trade in non-containerisable products may not be a good counterfactual to identify the effects of containerisation on containerisable products. Similarly some products may become containerisable later on, such as some food products. So our strategy in this chapter is to again use the bilateral variation in the adoption of the container rather than the cross-product variation.

In chapter 4, we introduced a product classification that dates back to 1968 which contains information about the containerisability of products. This classification identifies products at the 4-digit SITC product level that were suitable for the container in 1968 based on their physical properties. Products that were not suitable for the container in 1968 are classified as either of limited suitability or not suitable for the container. This is the only scientific classification available to us. This classification lends both advantages and disadvantages to our analysis.

The advantage of this classification is that it is conducted in the early years of containerisation. This means that we know what could be moved in containers in the early stages and we can be sure that these products were suitable for containers at the time and remained so thereafter. A disadvantage of using this classification is that it is static. The group of products classified as 'of limited suitability' or 'not suitable' for containers may include products that are sometimes containerisable or were strongly affected by containerisation because their intermediate inputs were. Some products may have become containerisable (adjusted to fit in containers) as containerisation caught on such as fresh produce and frozen foods. Some products were not and won't be transported in containers such as oil products. Other products are not containerisable but the supply chains that were enabled by containerisation meant that the trade of these products was strongly affected by containerisation. This was especially the case when just-in-time manufacturing gained popularity in the 1980s. This means that the group of products classified as non-containerisable contains elements that are endogenous to containerisation. Ideally, we want a classification that is updated as products are adjusted to become containerisable. But unfortunately, this classification does not exist as far as we are aware. Even if we had such a classification, we still wouldn't be able to account for those products that are non-containerisable but whose trade is affected by containerisation. An alternative would be looking at customs data on individual shipments to determine what was being transported in containers. This data is unavailable unfortunately for our period.

As a result, causal statements are clearer for the group of products that were containerisable in 1968, and less so for the group classified as non-containerisable. The results of the latter group are of interest and suggestive but the direction of causality is less clear.

Moving forward, we call 'containerisable' products those products that are classified as containerisable in the containerisability classification of 1968. We call 'non-containerisable' trade those products that are classified as partially suitable or not suitable for the container in 1968 in the same classification. We understand that the latter title is inaccurate as the group may contain products that may have become transportable in containers at the end of the period. However, we use these terms for convenience.

In this chapter, we use the containerisability classification of 1968 to restrict the sample of trade flows to the 4-digit containerisable products. We estimate the effects of containerisation on containerisable trade using a treatment estimation equation at the product level. We also use the containerisability classification at the 1-digit disaggregate product level constructed in chapter 4 for robustness. This chapter is divided as follows. In section 2, we discuss the empirical strategy and propose the estimation equation. In section 3, we estimate the effects of containerisation on containerisable trade at the 4-digit and 1-digit SITC product disaggregate levels. In section 4, we run some robustness regressions. In section 5, we explore heterogeneity in the results by restricting samples to North-North, North-South, and South-South containerisable trades. In section 6, we investigate the effects of containerisation on non-containerisable trade. We conclude in section 7.

6.2 Product Level Econometric Specification of the Effects of Containerisation on Containerisable Trade

In the previous chapter, we investigated the effects of containerisation on aggregate trade flows at the country level. In this section, we add an additional dimension to our estimation which is the product dimension. Our dependent variable becomes the log of trade flows at the SITC product level between countries i and j at time t. The treatment estimation equation becomes:

$$lnx_{ijkt} = \beta_1 + \beta_2 Container_{ijt} + \beta_3 Policy_{ijt} + \beta_4 \overrightarrow{D_{ijkt}} + u_{ijkt} \tag{6.1}$$

The variable *Container* in this specification measures the adoption of containerisation by both countries i and j at time t. This variable is product invariant. As in the previous chapter, this variable takes the value of 0 or 1. It switches to one when both countries on a trade route are containerised in year t. The policy variables control for trade and economic shocks that are country-pair time variant and these are FTAs, GATT members, and common currency in line with the previous chapter. This would solve for any potential omitted variable bias if containerisation is correlated with any of the other policy variables. For example, one might think that countries that share a free trade agreement are more likely to containerise if either country containerises. The second advantage of this specification is that it allows for a "horse race" between the technology variable and the policy variables. We also control for a host of dummies (it, jt, and ij) as in the previous chapter. We will also include product dummies in addition. These are summed by the vector D_{ijkt}.

The treatment group in this specification is all bilateral trade flows between two containerising countries. Our treatment variable is the bilateral container variable at time t. The control group is all bilateral trade flows in which either one country or none of the two countries are containerised. In other words, our counterfactual becomes all product trade flows between non-containerising country pairs[1].

At the 4-digit level between 1962 and 1990, we have 15,578,068 observations or positive trade relationships between 157 countries. Just like the previous chapter, we choose points in time that are 5 years apart to allow trade to adjust to containerisation. This reduces the sample to 2,237,820 observations. This is also necessary since with such a large sample, we are nearing the computational power limit of the statistical software package. The size of the sample does not allow for the inclusion of all exporter- and importer-time and country pair as well as product dummies. We deal with this by estimating a first-differenced version of the above equation. Also the first-differenced version of the equation allows for the possibility that the bilateral FE vary over 5-year periods. According to Wooldridge (2010)[2], first differencing a structural equation is a simple yet powerful method of programme evaluation.

Beside necessity, other potential problems are solved by first-differencing. First-differencing the panel yields some potential advantages over FE. Wooldridge (2010) notes that when the number of time periods exceeds two, the fixed-effects estimator is more efficient under the assumption of serially uncorrelated error terms. The first-differencing estimator is more efficient under the assumption that the error terms are

[1]One can think of a different specification in which the treatment group is containerisable products and the control group is non-containerisable products. This specification would ideally work if we had a product classification in which we are able to separate between containerisable and non-containerisable trade for all years. The containerisability classification allows us to separate between what we know is containerisable in 1968 and thereafter and what is classified as 'non-containerisable' in 1968 but for which we cannot be confident they stay so after 1968 as we argue in this chapter. We however propose a specification in appendix C in which we use the classification of 1968 to capture the effects of containerisation on 'containerisable' trade as opposed to 'non-containerisable'. We cannot draw any causal statements from the results however.

[2]page 320

serially correlated. It is quite plausible that the unobserved factors in trade flows, u_{ijt} are correlated over time. For instance, factors affecting the likelihood to containerise may be present in several time periods and hence serially correlated. One can think of the political will to invest in new container ports in a trade-promoting government or other political factors that might encourage a country to containerise following other countries or even competition between countries to become the regional hub. If the error terms are serially correlated then the FE estimates are inefficient and the inefficiency increases as T gets large. This suggests that differencing the data will increase estimation efficiency for our large panel.

In applying first differencing, we difference equation (6.1) to obtain the estimating equation. By first-differencing, the equation becomes:

$$\Delta lnx_{ijk,t} = \gamma_1 + \gamma_2 \Delta Container_{ij,t} + \gamma_3 \Delta Policy_{ij,t} + \gamma_4 \overrightarrow{D_{ijk}} + u_{ijk,t} \tag{6.2}$$

The estimates of the coefficients in the above equation should be interpreted in the original equation (6.1). The estimate of the coefficient from the above equation is the differences-in-differences estimator, i.e. $\hat{\gamma_2} = \Delta y_{treat} - \Delta y_{control}$. It is worth mentioning that the effect of containerisation is assumed to affect the growth of trade for a single 5-years period.

6.3 Product Level Estimations of the Effects of Containerisation on Containerisable Trade

As discussed in the introduction, we use a product containerisability classification which looks at the product characteristics to classify them as containerisable or not in 1968. Products classified as containerisable in this classification are suitable for transport in containers at the beginning of containerisation and remain so thereafter. We are therefore able to make causal statements about the effects of containerisation on containerisable trade.

Some products may have been adjusted later on to be moved in containers as containerisation caught on and some other products may be traded more intensively because their parts or inputs are containerisable. This means that we can have greater confidence that we identify the causal effects for those products that are classified as containerisable in 1968. Products classified as non-containerisable in 1968 may not remain so and their containerisability might be affected by containerisation itself. This means that their inclusion in the analysis might introduce an element of endogeneity. Any study of the effects of containerisation on these products is thus suggestive and may be somewhat biased. It is also difficult to determine the direction of any bias however.

For these reason, we will restrict our empirical estimation on containerisable products in this initial analysis. In this section, we estimate equation 6.2 to estimate the effects of containerisation on containerisable commodities. We estimate the effects of containerisation on containerisable trade at both the 4- and 1-digit SITC product levels as a robustness check.

In table 6.1, we estimate equation 6.2 to identify the effects of full containerisation (port and railway) in the top part and port containerisation only in the bottom part. We present the results for the 4-digit product level regressions in columns 1 to 3 and the 1-digit product level regressions in columns 4 to 6. We introduce FE gradually. We start by including it and jt dummies. We then introduce product dummies, and then product-year (kt) dummies. Product-year dummies should control for technological changes in product production and transportation.

The results in table 6.1 suggest that estimating the effects of containerisation on containerisable trade is robust to the product aggregation level and to the inclusion of product and product-year FE.

The coefficients of the full containerisation variables are very close to each other in magnitude in the 3 estimations (columns 1 to 3). The effect of containerisation on containerisable product trade is around 90%. This result is robust to the inclusion of product and product-year FE. Similarly, port containerisation alone leads to an average increase of approximately 68% in containerisable product trade and this estimate is also robust to the inclusion of product and product-year FE.

The effect of full containerisation is estimated to be around 93% on containerisable trade in the 1-digit industry regressions. The estimated coefficients are virtually equal to each other in columns 4-6. This means that the estimated effect is robust to the inclusion of product and product-year FE. The estimated effect of port containerisation in the bottom half of the table is around 76% on containerisable trade in columns 4-6.

With regards to the other policy variables, the effect of FTAs is therefore roughly one third to half the effect of containerisation. We estimate roughly similar effects for bilateral GATT memberships to FTAs.

In conclusion, Containerisation has strong and significant effects on containerisable trade in the range of 70 to 90% depending on the level of product aggregation and whether we allow for containerisation on rail (full containerisation). Signing a free trade agreement has roughly the same effect on containerisable trade as a bilateral signing up to GATT. Also, the results suggest that the effect of containerisation is equal to the effects of FTAs and GATT combined. In the next section, we will test the robustness of these results to the selection of data points in time, time intervals, and sub-samples.

Table 6.1: Effects of Containerisation on Containerisable trade, Product level regressions, 5-year Intervals and 7 periods

		4-digit SITC product level			1-digit SITC product level		
		(1)	(2)	(3)	(4)	(5)	(6)
		1st Diff	1st Diff	1st Diff	1st Diff	1st Diff	1st Diff
Port and Railway	Full cont(ij)	0.645***	0.651***	0.633***	0.654***	0.659***	0.655***
		(0.00658)	(0.00655)	(0.00652)	(0.0197)	(0.0196)	(0.0196)
	FTA	0.336***	0.339***	0.332***	0.287***	0.287***	0.279***
		(0.00940)	(0.00934)	(0.00927)	(0.0405)	(0.0404)	(0.0404)
	Both GATT	0.355***	0.350***	0.344***	0.227***	0.232***	0.228***
		(0.00992)	(0.00987)	(0.00980)	(0.0268)	(0.0267)	(0.0267)
	Com Cur	0.143***	0.138***	0.135***	0.144*	0.140*	0.134*
		(0.0169)	(0.0168)	(0.0167)	(0.0574)	(0.0572)	(0.0572)
	N	1731210	1731210	1731210	175425	175425	175425
	R^2	0.077	0.089	0.106	0.122	0.127	0.130
	FE	it,jt	it,jt,k	it,jt,kt	it,jt	it,jt,k	it,jt,kt
Port Containerisation	Port cont(ij)	0.525***	0.526***	0.511***	0.564***	0.569***	0.564***
		(0.00601)	(0.00598)	(0.00595)	(0.0189)	(0.0189)	(0.0188)
	FTA	0.325***	0.327***	0.320***	0.261***	0.261***	0.253***
		(0.00940)	(0.00935)	(0.00928)	(0.0405)	(0.0404)	(0.0404)
	Both GATT	0.390***	0.386***	0.378***	0.235***	0.241***	0.236***
		(0.00991)	(0.00986)	(0.00979)	(0.0268)	(0.0267)	(0.0267)
	Com Cur	0.142***	0.138***	0.135***	0.142*	0.139*	0.132*
		(0.0169)	(0.0168)	(0.0167)	(0.0574)	(0.0573)	(0.0572)
	N	1731210	1731210	1731210	175425	175425	175425
	R^2	0.076	0.088	0.105	0.121	0.126	0.128
	FE	it,jt	it,jt,k	it,jt,kt	it,jt	it,jt,k	it,jt,kt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.4 Some Robustness Regressions for the 1-digit and 4-digit Product Level Estimations

After checking the robustness of the first estimations to the choice of product disaggregate level, we now turn to other robustness checks. Namely, we look at the length of the time intervals, the choice of data points (years), the sample break, and the exclusion of the Comecon countries, and the containerisability of refrigerated products. We also include a test for endogeneity that we introduced in the previous chapter in which we drop the top 5 trading partners for each country but at the industry level. We will follow the practice of estimating all models for both full containerisation and port containerisation separately.

In table 6.2, we run our robustness checks on trade flows at the 1-digit and 4-digit product levels and exhibit the results side by side. In the first two columns, we choose data points in time that are 3 years apart instead of 5 years that we chose earlier. Recall that our earlier choice of 5-year intervals is based on evidence from the UK and Japan in chapter 4. The years of choice become: 62, 65, 68, 71, 74, 77, 80, 83, 86, and 90. So now, we have 10 data points instead of 7. The results suggest that our estimates are robust to the choice of the length of adjustment. As expected, the estimates of the container effects are lower when the period of adjustment allowed is lower. Nonetheless, the effects of full containerisation on trade flows at the 1- and 4-digit level are strong and significant. The estimates of the effect of full containerisation are around 47% and 53% for the 1- and 4-digit product level estimations respectively; the estimated effects of port containerisation are 42% and 47% respectively. This exercise is suggestive that the effect of containerisation is not contemporaneous and may linger on many years later which is supported by the narrative. In chapter 7, we explore whether the effects can be felt 5 and 10 years after containerisation.

In columns 3 and 4, we choose different data points that are 5 years apart. Recall that previously, we chose the following data points (years): 62, 67, 72, 77, 82, 87, and 90. In this exercise, we choose the years 62, 65, 70, 75, 80, 85, and 90. The results suggest that our estimates are robust to the choice of years. The estimates for the effects of full containerisation on containerisable trade are around 88% and 91% for the 1- and 4-digit level estimations respectively. This is not much different than the estimates we find in table 6.1 (columns 3 and 6).

In columns 5 and 6, we test for any breaks in the sample. The reason why we do this is that the trade data sample is restricted to a group of 72 countries only between 1984-1990. Any break, therefore, is expected to take place in 1984. We choose data points that are at 5-years apart and the first year after the break is 1987. Since we estimate a first-differenced model, then any effects from the break in the sample would be picked up in the differenced data in the interval 1982-1987. We drop the differenced data at 1987 to check for robustness of our estimation to this break. We still pick up strong and significant effect for full containerisation on containerisable trade at both product disaggregate levels. The estimated effect of around 68% is slightly lower than the estimated effect in table 6.1. The estimated effect for port containerisation is approximately 50%. Our estimates are thus robust to any possible breaks in the sample.

Furthermore, we remove the ex-Comecon countries plus India from the sample in columns 7 and 8. Comecon stands for The Council for Mutual Economic Assistance. Although many of these countries did containerise, they were fairly closed economies and traded a lot among each other. The ex-Comecon countries are: Bulgaria, Czechoslovakia, Hungary, Poland, Romania, USSR, Albania, East Germany, Mongolia, Cuba, and Vietnam. Removing these countries does not have any noteworthy effects on the estimates. If anything, the coefficient estimates of the full and port containerisation variables are ever so slightly higher than the estimates in the entire sample regressions.

We also test the robustness of the results to the containerisability of refrigerated products. These are products that we know have become containerisable after the introduction of refrigerated containers. We list these products in the appendix (table C1). We allow these products to be containerisable in our sample at the 4-digit product level. Running the same regression on the new sample of containerisable products at the 4-digit product level results in similiar estimates of the effects of port and full containerisation to the estimates in column 3 of table 6.1. At the 1-digit industry level, we allow industry 0 (Food and live animals) to be containerisable while it was considered as non-contanerisable in table 6.1. Allowing industry 0 to be containerisable produces estimates for port and full containerisation that are in line with the estimates in column 6 of table 6.1. Our estimates are therefore robust to the containerisability of refrigerated products.

Finally, dropping the top 5 trading partners by industry for each country i does not change the results in table 6.1 whether for full and port containerisation or at the 4-digit and 1-digit industries . The top 5 trading partners were eliminated by taking the average value by industry between any two countries i and j across all years and eliminating the top 5 trading partners for each country i by industry.

Since we are not testing the robustness of the other policy variables estimates in this section, we will not comment on those estimates. However, it is noteworthy that in almost all robustness checks, the container effects is larger than the effects of the policy variables and the conclusions reached in the previous section with this regard are valid here.

In conclusion to this section, our estimates of the effects of containerisation on containerisable trade are robust to the length of the adjustment period, the choice of the 5-year interval data points (years), the sample break, the exclusion of the Comecon countries plus India, the containerisability of refrigerated products, and the elimination of the top 5 trading partners by industry.

6.5 Heterogeneity: Estimations for North-North / South-South / North-South Trade

Economic commentators such as Levinson (2006) are of the opinion that containerisation helped integrate East Asia with the world economy. In chapter 4, we show from product level data how the composition of trade between North and South has changed after the containerisation adoption was completed. If containerisation has helped the fragmentation of the production process and hence led to change in the composition of trade, do we find evidence that containerisation has affected North-South trade more than other trades as the narrative suggests? After running some robustness checks on our product level estimations, we now turn to this rather interesting question[3].

To answer this question, we restrict our data set to samples of the respective groups we are interested in and estimate equation 6.2. Here too, we estimate the effects of full and port containerisation at both the 1- and 4-digit product levels.

Table 6.3 confirms that containerisation affected North-South containerisable trade the most, then South-South trade, and North-North trade the least. This result is robust to the product disaggregate level. In magnitude, depending on the product disaggregate level, the effect is between 158% and 269% for North-South trade, between 99% and 110% for South-South trade, and between 28% and 40% for North-North trade. The coefficient estimates are generally lower in the port containerisation estimations with the exception of South-South regressions, where the coefficient estimates are either very close or slightly higher than the full containerisation coefficients. This reflects the prominence of railway in European trade and the introduction intermodal cargo transportation in North countries. In South countries, containerisation was restricted to ports in most cases if we ignore roads.

That containerisation affected North-South containerisable trade the most is a re-

[3]Recall that North countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, Fm German FR, France, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and USA. South countries are all other countries

Table 6.2: Effect of Containerisation, Robustness checks, Containerisable Trade only

		3-year intervals		Different data points		dropping 1987		excl Comecon & India		incl refrigerated products		dropping top trading partners	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		4-digit	1-digit	4-digit	1-digit	4-digit	1-digit	4-digit	1-digit	4-digit	1-digit	4-digit	1-digit
Port and Railway	Full cont(ij)	0.423***	0.387***	0.646***	0.633***	0.519***	0.509***	0.651***	0.693***	0.634***	0.655***	0.596***	0.641***
		(0.0047)	(0.0152)	(0.0068)	(0.0192)	(0.0068)	(0.0211)	(0.0068)	(0.0210)	(0.0063)	(0.0181)	(0.0069)	(0.0199)
	FTA	0.240***	0.189***	0.220***	0.212***	0.362***	0.278***	0.350***	0.301***	0.341***	0.252***	0.318***	0.282***
		(0.0084)	(0.0375)	(0.0093)	(0.0407)	(0.0100)	(0.0469)	(0.0093)	(0.0407)	(0.0090)	(0.0380)	(0.0098)	(0.0417)
	Both GATT	0.290***	0.199***	0.262***	0.201***	0.317***	0.183***	0.310***	0.210***	0.344***	0.242***	0.346***	0.217***
		(0.0079)	(0.0229)	(0.0095)	(0.0260)	(0.0102)	(0.0285)	(0.0104)	(0.0288)	(0.0096)	(0.0247)	(0.0102)	(0.0269)
	Com Cur	0.0922***	0.058	0.0292	0.057	0.133***	0.138*	0.146***	0.0544	0.135***	0.0993	0.164***	0.127*
		(0.0138)	(0.0479)	(0.227)	(0.0521)	(0.0170)	(0.0582)	(0.0170)	(0.0598)	(0.0162)	(0.0528)	(0.0179)	(0.0600)
	N	2916513	281659	1662604	174376	1567536	150156	1564278	154040	1820826	209420	1602621	170183
	R^2	0.099	0.115	0.116	0.140	0.094	0.123	0.111	0.135	0.104	0.120	0.105	0.130
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt
Port Containerisation	port cont(ij)	0.387***	0.349***	0.523***	0.563***	0.408***	0.420***	0.527***	0.591***	0.518***	0.575***	0.469***	0.551***
		(0.00451)	(0.0151)	(0.0062)	(0.0185)	(0.0062)	(0.0202)	(0.0063)	(0.0202)	(0.0058)	(0.0175)	(0.0062)	(0.0191)
	FTA	0.226***	0.174***	0.199***	0.174***	0.350***	0.247***	0.326***	0.258***	0.330***	0.226***	0.307***	0.255***
		(0.0084)	(0.0375)	(0.0093)	(0.0407)	(0.0101)	(0.0469)	(0.0093)	(0.0407)	(0.0090)	(0.0380)	(0.0098)	(0.0417)
	Both GATT	0.335***	0.212***	0.340***	0.223***	0.345***	0.188***	0.329***	0.208***	0.378***	0.249***	0.379***	0.225***
		(0.00791)	(0.0229)	(0.0094)	(0.0261)	(0.0102)	(0.0286)	(0.0104)	(0.0288)	(0.0095)	(0.0247)	(0.0102)	(0.0269)
	Com Cur	0.0925***	0.0603	0.031*	0.0594	0.133***	0.136*	0.144***	0.0507	0.134***	0.0981	0.162***	0.124*
		(0.0138)	(0.0479)	(0.0151)	(0.0521)	(0.0170)	(0.0582)	(0.0170)	(0.0599)	(0.0162)	(0.0528)	(0.0180)	(0.0600)
	N	2916513	281659	1662604	174376	1567536	150156	1564278	154040	1820826	209420	1602621	170183
	R^2	0.099	0.096	0.115	0.139	0.093	0.122	0.110	0.134	0.103	0.119	0.104	0.129
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

markable result. This could be a consequence of the change of the composition of trade between North and South after containerisation. Before containerisation, North-South containerisable trade was dominated by the trade in basic commodities such as coffee, cotton, and copper. After containerisation, there was a clear shift towards new trade in which South countries have become suppliers of manufactures and containerisable finished products to North countries. This result suggests that containerisation had a strong effect on containerisable trade between North and South countries by encouraging the fragmentation of the production process allowing South countries to develop into suppliers to North countries.

Also, that South-South containerisable trade was affected could reflect the strengthening economic position of many of the South countries in Asia and the Middle East. But this could also be a result of the fragmentation of production process itself. Parts and intermediate inputs are transported many times between countries where some value is added in each step. Another channel in which trade could have been stimulated in South South trade is that building new ports allowed many countries to trade which couldn't previously trade because of poor infrastructure or perhaps the new hub and spoke systems allowed these countries to send their goods to the nearest biggest port where shipping lines care to call.

While containerisable trade was affected positively by containerisation in North-North trade, the effect is smaller than in North-South or even South-South trade. This could be a direct result of the new economic order in which South countries supply North countries which means that relatively North-North countries trade less with each other than they do with South countries.

We also find interesting results for the other policy variables. Of all country groups, FTAs have the biggest effect on North-North containerisable trade followed by South-South and then North-South. There are more North-North FTAs than South-South and North-South FTAs in our sample period (1962-1990)[4]. Most of the FTAs in our sample are related to the European Community. The effect of the FTAs on containerisable trade between North countries is very similar to the effect of full containerisation among these countries. However, what is perhaps a more interesting result is that GATT

[4]The only FTAs between North and South countries in the years 1962-1990 were EC-Algeria, EC-Syria, and Israel-USA.

membership seems to affect North-South and South-South containerisable trade but has no significant effect on North-North trade. This could be because membership in the EC preceded GATT membership for many European countries and hence these countries were already in a free trade agreement.

To conclude, containerisation affected North-South containerisable trade the most, followed by South-South, and then North-North containerisable trade the least. The effects of containerisation on North-South containerisable trade are quite large and range between around 158 and 269%. This reflects a change in the composition of trade between North and South. While traditionally this trade was dominated by moving basic commodities from South to North, the narrative suggests that the container allowed South countries to resume a new role in the world economy. The fragmentation of the production process and the longer supply chains means that South countries have become suppliers of finished containerisable goods.

Table 6.3: Effect of Containerisation, Heterogeneity in Results

	Dep.Var: ln trade(ijk)	4-digit Industry Level Flows			1-digit Industry Level Flows		
		North-South Trade	North-North Trade	South-South Trade	North-South Trade	North-North Trade	South-South Trade
Port and Railway	Full Cont(ij)	0.949***	0.334***	0.686***	1.306***	0.245***	0.745***
		(0.0106)	(0.0124)	(0.0171)	(0.0447)	(0.0677)	(0.0373)
	FTA	0.080*	0.409***	0.212**	0.242*	0.253***	0.408**
		(0.0390)	(0.0097)	(0.0678)	(0.122)	(0.0348)	(0.148)
	Both GATT	0.510***	0.053	0.244***	0.215***	0.028	0.215***
		(0.0154)	(0.0311)	(0.0207)	(0.0521)	(0.106)	(0.0449)
	Common Curr	0.178***	0.170***	-0.093	0.221**	0.422**	0.0837
		(0.0208)	(0.0423)	(0.0585)	(0.0744)	(0.148)	(0.119)
	No. Countries	157	22	135	157	22	135
	No. Observations	1028251	481174	221785	107993	17641	49791
	overall R^2	0.112	0.117	0.142	0.158	0.143	0.152
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt
Port Containerisation	Port Cont(ij)	0.753***	0.295***	0.657***	0.705***	0.126*	0.773***
		(0.0095)	(0.0120)	(0.0174)	(0.0338)	(0.0550)	(0.038)
	FTA	0.058	0.401***	0.203**	0.242*	0.245***	0.408**
		(0.0390)	(0.0097)	(0.0679)	(0.122)	(0.0350)	(0.148)
	Both GATT	0.592***	0.087**	0.244***	0.279***	0.041	0.218***
		(0.0154)	(0.0310)	(0.0207)	(0.0521)	(0.106)	(0.0449)
	Common Curr	0.174***	0.171***	-0.103	0.222**	0.425**	0.078
		(0.0209)	(0.0423)	(0.0585)	(0.0746)	(0.148)	(0.119)
	No. Countries	157	22	135	157	22	135
	No. Observations	1028251	481174	221785	107993	17641	49791
	overall R^2	0.120	0.116	0.141	0.155	0.143	0.152
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.6 Estimating the effects of containerisation on containerisable and non-Containerisable trade

So far we have estimated the effects of containerisation on containerisable trade. To estimate the effects of containerisation on both containerisable and non-containerisable trade would be introducing endogenous components since some products may become containerisable as containerisation caught on as we discussed before. Estimating equation 6.2 for these products can only be of interest and suggestive but the direction of causation is less clear.

In table 6.4, we estimate the effects of containerisation on non-containerisable and containerisable trade. We estimate the effects of containerisation on non-containerisable trade and all products at the 4-digit product disaggregate level in columns 1 and 2 and at the 1-digit product level in columns 3 and 4.

Looking at the coefficients reveals two things. Containerisation seems to have affected trade in non-containerisable goods. In magnitude, the effects of full containerisation on non-containerisable trade are between 107 and 112% depending on the product disaggregate level. As for port containerisation, the estimated coefficient is slightly lower than the full containerisation coefficient in column 1 (4-digit) and slightly higher in column 3. This could be explained by the fact that some non-containerisable products such as oil are usually not transported by rail inland. Hence, railway containerisation would not have an additional effect on the trade in these products.

In columns 2 and 4, the effects of full containerisation on all products (containerisable and non-containerisable) are estimated between 97 and 100% respectively. The coefficients of the port containerisation variable are slightly lower in both columns.

The result that containerisation affected all products, containerisable and non-containerisable can only be suggestive as we argued and maybe biased. It is also difficult to determine the direction of any such bias. We cannot be sure of the direction of causality. This is mainly because the trade in products classified as 'non-containerisable' may have justified their adjustment to move them in containers later on. Also, if containerisation allowed for the fragmentation of the production process and the trade in intermediate inputs, then the trade in finished goods may have been stimulated by containerisation even if the finished product itself is not moved in containers.

To conclude, containerisation seems to have affected both containerisable and non-containerisable trade. We are however unable to make the claim that the effect on what is classified as non-containerisable in our product classification is causal as many products may have been adjusted to fit in containers or have been affected by containerisation because the trade in their parts/inputs is stimulated by containerisation itself.

Table 6.4: Effect of Containerisation on containerisable and non-containerisable trade

		4-digit		1-digit	
		(1)	(2)	(3)	(4)
		Non-containerisable	All products	Non-containerisable	All products
Port and Railway	full cont(ij)	0.753***	0.680***	0.729***	0.692***
		(0.0120)	(0.00576)	(0.0373)	(0.0175)
	FTA	0.357***	0.347***	0.257**	0.287***
		(0.0177)	(0.00831)	(0.0790)	(0.0365)
	Both GATT	0.358***	0.360***	0.410***	0.278***
		(0.0198)	(0.00891)	(0.0531)	(0.0242)
	Com Cur	0.127***	0.142***	0.0139	0.0998
		(0.0332)	(0.0151)	(0.109)	(0.0513)
	N	506610	2237820	61681	237106
	R^2	0.081	0.069	0.128	0.108
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt
Port Containerisation	port cont(ij)	0.663***	0.567***	0.752***	0.636***
		(0.0115)	(0.00534)	(0.0368)	(0.0170)
	FTA	0.349***	0.337***	0.241**	0.264***
		(0.0177)	(0.00832)	(0.0789)	(0.0365)
	Both GATT	0.410***	0.400***	0.428***	0.289***
		(0.0197)	(0.00890)	(0.0530)	(0.0242)
	Com Cur	0.126***	0.141***	0.0167	0.0987
		(0.0332)	(0.0151)	(0.109)	(0.0513)
	N	506610	2237820	61681	237106
	R^2	0.080	0.068	0.129	0.107
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.7 Chapter Conclusion

Not all products are moved in containers. This may help explain the weak results reached in the previous chapter when we consider aggregate trade flows. This is why we consider containerisable products in this chapter to identify the effects of containerisation. We use the product containerisability classification introduced in chapter 4 to identify those products that are moved in containers. We argue that this classification is convenient since it goes back to 1968, the beginning of containerisation. We can therefore be confident that products that are deemed containerisable in 1968 can be moved in containers at the start of the process and remain so after. We cannot be sure about products that are classified as non-containerisable however. This is because this group may contain products that may become containerisable or products whose trade may be affected by containerisation owing to their parts/intermediate products which are containerisable. Hence these products introduce endogenous elements in our regressions. As a result, causal statements are cleaner for products that are classified as containerisable in 1968.

We identify the effects of containerisation in a treatment type equation in which the dependent variable is the 1-digit or 4-digit SITC product trade flows. The identification of the container effects comes from the treatment group which is the containerisable products trade between two containerising countries and the control group which is the same trade between non-containerising countries. We first-difference the estimation equation and include importer- and exporter-time as well as product FE to deal with endogeneity bias. This specification has many advantages such as allowing the bilateral FE to vary over 5-year periods. It also delivers an efficient estimator when we have serial correlation in the data. We estimate the equation with port and full container variables separately.

The empirical results return economically and statistically significant results for the effect of containerisation on containerisable trade. The effect is estimated to be around 90% for full containerisation and 70% for port containerisation. The results are robust to the product disaggregation level. The relatively large effect for the container is around twice the individual effect of FTAs and GATT membership on containerisable trade and up to six times the effect of common currency. We also perform several robustness checks for these results and find them to be robust to the choice of years in the pooled panel, the length of the time intervals, controlling for a possible break, and the exclusion of the Comecon countries.

In answering whether containerisation affected North-South trade as the narrative suggests, we restrict our estimation to subsamples of North-North, North-South, and South-South trade and estimate equation 6.2 for each sub-sample separately. What we find is that containerisation had the largest effects on North-South trade. This result and evidence from chapter 4 in which new patterns of trade are clear suggest that containerisation aided in promoting North-South trade and the new patterns of trade. The effects of containerisation in ports and rail on North-South containerisable trade is estimated around 160% when considering 4-digit SITC product disaggregate level. The effect is lower for South-South and North-North containerisable trade. This effect is estimated around 100% and 28% respectively. Hence, containerisation is estimated to have affected North-South (containerisable) trade the most followed by South-South and then North-North containerisable trade the least.

In this chapter, we investigate the contemporaneous effects of containerisation. One obvious question may arise. Were the effects of the container only contemporaneous or could they still be felt many years later? In the next chapter, we investigate whether containerisation had effects 5 and 10 years after bilateral adoption of the technology.

Chapter 7

Dynamic Effects of Containerisation on International Trade

7.1 Introduction: Dynamics

> *"Only with time, as container shipping developed into an entirely new system of moving goods by land and sea, did it begin to affect trade patterns and industrial location."*[1]

Containerisation is a technological change that was adopted by different countries at different times and in varying degrees. In most countries, the adoption was implemented gradually. In the UK, containerisation started in a few ports and on the rail first before new container ports were built from scratch such as Felixstowe and Tilbury. Even when ports became equipped with container handling equipment, it took time before trade adjusted to the new technology. Naturally, not all shipping lines had container ships or containers in business at the time of adoption. It took around 5 years in the UK and Japan before around 50% of all containerisable trade was actually moved by containers. One may expect different countries to adjust at different rates. Also many of the efficiencies and savings brought about by the container were not felt immediately. It is true that once goods were transported in the box, then problems like pilferage and damage are solved immediately and port efficiencies increase. But some savings such as labour costs and time savings at port only came later on as the industry switched from being labour intensive to being capital intensive. Similarly, many of the advantages of containerisation such as intermodal transportation, the development of the hub and spoke systems, expansions of ports, etc. take time to be accomplished. All of the above

[1] Levinson (2006) page 13.

suggest that while the effects of containerisation are immediately felt, these effects are likely to be felt years later. This motivates this chapter.

It is thus reasonable to assume that containerisation that is adopted bilaterally in 1970 might still have an effect on trade 10 years later in 1980. To capture the cumulative effect on trade of containerisation, we introduce lagged and lead treatment variables in the estimation specification.

Besides capturing lagged effects, including lagged regressors in the estimation equation solves for the potential lack of strict exogeneity. According to Wooldridge (2010)[2], when lagged regressors are correlated with the error terms, we can solve the lack of strict exogeneity by including lags. Also, Wooldridge suggests that it is possible to test for the 'strict exogeneity' in our context by adding a future level along with lagged terms of the treatment variable to the equation.

In the previous chapter, we set down our empirical strategy to estimate the effects of containerisation on containerisable trade flows at the product level. In doing so, we used information about the nature of products and their suitability for transportation in containers. We used two levels of product level aggregation, the 1- and 4-digit SITC product level classifications. The specification employed is an average treatment specification to identify the effects of containerisation. The specification employed is given by equation 6.2.

When introducing first lagged and first lead independent variables in the specification, the estimation equation becomes:

$$\begin{aligned}\Delta lnx_{ijkt} = \quad & \beta_1 + \beta_2 \Delta Container_{ijt} + \beta_3 \Delta Container_{ij,t-5} + \beta_4 \Delta Container_{ij,t+5} \\ & + \beta_5 \Delta Policy_{ijt} + \beta_6 \Delta Policy_{ij,t-5} + \beta_7 \Delta Policy_{ij,t+5} + \beta_8 \overrightarrow{D_{ijkt}} + u_{ijkt}\end{aligned} \tag{7.1}$$

The container treatment variable is $Container_{ijt}$ which is country pair specific. Similar to the previous chapter, we consider containerisable trade in this chapter. We argued in the previous chapter that our product containerisability classification goes back to 1968 and products that are classified as 'non-containerisable' might include endogenous elements since products may become containerisable or may be affected through

[2]Wooldridge (2010) page 322

their parts. As before, the treatment group is containerisable trade flows between two containerising countries. The control group is containerisable trade flows between non-containerising country pairs. Non-containerising country pairs are the country pairs or trade routes in which either one country or none is containerised. We also introduced 3 policy treatment variables which are FTAs, GATT memberships, and common currency. This has the benefit of solving for possible omitted variable bias if the container variable is correlated with any of the policy variables as well as allow a horse run between the technology and policy variables. The lagged terms $Container_{ij,t-5}$ and $Policy_{ij,t-5}$ capture any lingering effects for the treatment variable in question in the future. The lead terms $Container_{ij,t+5}$ and $Policy_{ij,t+5}$ capture whether there is any pre-treatment effect and serve as a test for exogeneity as we discussed earlier.

This chapter is divided as follows. In section 2, we first estimate equation 7.1 with lagged and lead variables at the 4-digit and 1-digit product aggregate levels for containerisable trade. In section 3, we try to interpret the lead container variable by testing whether it includes a trend component. In section 4, we use the narrative to test for strict exogeneity in North North containerisable trade since we do not expect any feedback effects from containerisation in that sample. In section 5, we estimate the same equation with the lagged and lead terms for North-South and South-South containerisable trades to investigate heterogeneity in the cumulative effects of containerisation in line with the previous chapter. In section 6, we plot a diagram to show the development of (containerisable) trade following treatment and we conclude in section 7.

7.2 Cumulative effects of Containerisation: Introducing Lags and Leads of Treatment Variables

In this section we estimate equation 7.1 to identify the effects of containerisation. We introduce lagged and lead treatment variables gradually to allow for cumulative/lagged effects. We estimate the treatment effects at both the 1- and 4-digit product levels. We only consider full containerisation to allow for the cumulative effects of both port and rail containerisation. Since we are introducing lagged treatment effects, we will be calculating what we term as Total Treatment Effect (TTE) in each of the tables to add up the compounded treatment effects of containerisation and the policy variables. We include the cumulative effect of containerisation in the estimation tables and term those

Total Container Effect (TCE). As in the previous chapter, we will restrict our sample to containerisable trade only. The reasons for this were dealt with in the previous chapter in length. Briefly, the classification that we use to identify the effects of containerisation dates back to 1968. These are the products for which we can be confident that any causal statements can be made.

In tables 7.1 and 7.2, we choose to include up to 2 lagged terms since we have 7 points in time and the bulk of the countries containerise after 1975, which leaves us with only 2 time periods after the last countries containerise in our sample. In table 1, we present the 1-digit industry regressions while in table 2, we present the 4-digit product level regressions. In column 1, we do not include any lagged variables but 1st lead variables. In column 2, we include 1st lagged variables and in column 2, we include 1st and 2nd lagged variables as well as 1st lead variables. A 1st lagged variable means lagging a variable 1 period (t-1) which is equivalent to 5 years in our setting. A 2nd lagged variable means lagging a variable 2 periods (t-2) or 10 years. A 1st lead variable means moving a variable 1 period (t+1).

There are a few things that we can conclude from our estimations. First of all, containerisation doesn't have just a one-off effect but lagged effects as well. The estimations in the two tables suggest that containerisation has large contemporaneous and lagged effects on containerisable trade and the lagged effects die out slowly. In table 1, total (cumulative) treatment effect (TTE) of the container variable is around 99% in column 1, 200% in column 2, and 165% in column 3. This means that containerisation had cumulative effects on containerisable trade of around 165% to 200% 10 to 15 years after the bilateral adoption of containerisation.

Similarly, in table 2, the 4-digit level regressions suggest that the effects of containerisation are still present in the data 10-15 years after introduction. The contemporaneous and lagged effects are larger than what we have seen in the 1-digit industry regressions. The cumulative or the TCE effect ranges from 93% in columns 1 with no lagged variables, to 249% in column 2 with 1 lagged variable, to 450% in column 3 when we include 2 lagged container variables.

Beside the lags, the estimations also suggest positive and significant coefficients for the lead container term in these estimations. The lead effect is much smaller than the contemporaneous effect however.

The fact that we are picking up a lead effect for the full containerisation treatment variable could mean one of three things. We could be picking up a pre-existing trend or a pre-container effect. If these two possibilities are ruled out, then there is a possibility that the containerisation measures suffer from weak endogeneity judging by the small magnitude of the lead container variable coefficient.

A pre-container effect could be the result of several things. One of the things that comes to mind is the spill-overs from a one-sided containerisation or in other words the containerisation of one of two countries on a particular trade route. We know that at the start of containerisation, only a handful of countries - mainly North countries - had container facilities for the handling of containerisation. This meant that most of the world trade routes were not containerised as defined by our container variable in the estimation equation which requires bilateral containerisation on a trade route. But one cannot ignore that even with one-sided containerisation, trade could still benefit from the new technology. We know that in the early years of containerisation, many shipping lines deployed container ships with cranes onboard to allow for loading and unloading of containers in unequipped ports. Even later on when cranes onboard were abolished, containerisation was a compelling force that ships would be stripped off their containers using ropes and pulleys sometimes on the high sea (Comoros Islands in the 1980s: Figure 4.16 chapter 4). We test whether the lead variable coefficient is indeed capturing all of these things later. More about this later.

Sources of endogeneity could be omitted variable bias, simultaneity bias and/or measurement error. Omitted variable bias is dealt with by first-differencing the data and including country-time and product-time FE. Simultaneity bias is unlikely since the dependent variable is 4-digit product trade flow between countries i and j whereas the technology variable is ij specific. Heavily traded routes perhaps are more likely to containerise, for example, albeit this problem would only be a limited one given the magnitude of the lead coefficients relative to the level coefficients and since the dependent variable and the regressor are of different dimensions. Measurement error cannot be ruled out since our container measure does not capture containerisation on the road but only in ports and rail. In section 7.4, we will use the narrative to minimise any measurement error in the container variable.

With respect to the other policy variables, we find a consistent contemporaneous effect of FTAs on containerisable trade of around 34% in the 1-digit regressions and 40% in the 4-digit regressions. TCE of FTAs is between 59% (table 7.1) and 75% (table 7.2) when 2 lagged container terms are included. These estimates are close to the estimated TTE of FTAs by Baier and Bergstrand (2007) when employing the same model on aggregate trade data. The model estimates a lead FTA or pre-FTA effect in columns 3 which was not estimated by Baier and Bergstrand (2007). The TTE of FTAs is only around one-sixth or one-seventh of the TTE estimated for the container. The treatment effects of GATT membership is approximately one-tenth the estimated total effect of the container. The TTE of common currency is between one-tenth and one-sixth that of containerisation.

To summarise, we find that containerisation, once adopted by the two partners on a give route, has effects on containerisable product trade that persist 10-15 years later. The TCE accounting for the 1st and 2nd lagged effects, is between 165% and 450% depending on the product disaggregation level. The TTE of the container is multiple times the treatment effects of the policy variables. The TTE of containerisation is 6 to 10 times the TTE of the individual policy variables. We also pick up a lead containerisation coefficient but the estimate thereof is relatively small compared to the contemporaneous variable coefficients. We investigate this lead variable coefficient further in the next two sections.

7.3 Understanding the Container First Lead Variable

In the previous section, we introduced lagged and lead effects of the container treatment variable to check whether containerisation had a one-off effect or the effects of the new technology lingered on after introduction. In the process, we also introduced a 1st lead treatment variable.Wooldridge (2010) states that including a lead variable is a good way of checking for strict exogeneity in the type of specification that we employ here. Estimating a significant coefficient for the lead container variable could therefore signal a pre-treatment effect, a pre-existing trend in trade, or weak endogeneity.

In the above estimations, we estimate positive and significant coefficients for the lead container term. Although, these coefficients are small compared to the contemporaneous container treatment variable coefficient, we try to understand what this lead effect is. Namely, in this section, we explore the possibility of a pre-existing trend.

Table 7.1: Introducing lags and leads of Full Containerisation: First Differenced Model (by ijk); 1-digit Industries: Containerisable Trade

	(1) difflnvalue	(2) difflnvalue	(3) difflnvalue
diffcont_ij	0.690***	0.917***	0.888***
	(0.0201)	(0.0243)	(0.0306)
difflag1		0.354***	0.262***
		(0.0211)	(0.0287)
difflag2			-0.0818**
			(0.0256)
difflead1	0.180***	0.250***	0.212***
	(0.0214)	(0.0234)	(0.0249)
diffrta	0.283***	0.269***	0.281***
	(0.0404)	(0.0407)	(0.0424)
difflag1rta		0.0869*	0.0997*
		(0.0413)	(0.0421)
difflag2rta			0.146**
			(0.0538)
difflead1rta	0.0990*	0.0304	0.132**
	(0.0422)	(0.0432)	(0.0510)
diffbothgatt	0.227***	0.254***	0.249***
	(0.0267)	(0.0296)	(0.0305)
difflag1bothgatt		0.0884***	0.0635*
		(0.0258)	(0.0288)
difflag2bothgatt			-0.0676*
			(0.0281)
difflead1bothgatt	-0.0893*	-0.102**	-0.106**
	(0.0367)	(0.0364)	(0.0366)
diffcomcur	0.136*	0.157	0.383**
	(0.0572)	(0.0900)	(0.131)
difflag1comcur		0.135*	0.0737
		(0.0583)	(0.0935)
difflag2comcur			0.0760
			(0.0647)
difflead1comcur	0.0318	0.128	0.133
	(0.0990)	(0.154)	(0.192)
N	175425	159277	146689
R^2	0.130	0.136	0.140
TCE	99%	193%	165%

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7.2: Introducing lags and leads of full containerisation: First Differenced Model (by ijk); 4-digit SITC product level: Containerisable trade

	(1) difflnvalue	(2) difflnvalue	(3) difflnvalue
diffcont_ij	0.659***	1.016***	1.346***
	(0.00658)	(0.00938)	(0.0125)
difflag1		0.546***	0.792***
		(0.00751)	(0.0112)
difflag2			0.383***
			(0.00953)
difflead1	0.212***	0.240***	0.270***
	(0.00738)	(0.00844)	(0.00892)
diffrta	0.335***	0.336***	0.337***
	(0.00928)	(0.00999)	(0.0109)
difflag1rta		0.178***	0.187***
		(0.0102)	(0.0108)
difflag2rta			0.130***
			(0.0139)
difflead1rta	-0.0247*	0.000163	0.0606***
	(0.00985)	(0.0108)	(0.0150)
diffbothgatt	0.343***	0.356***	0.315***
	(0.00980)	(0.0116)	(0.0123)
difflag1bothgatt		0.130***	0.0928***
		(0.00962)	(0.0112)
difflag2bothgatt			-0.0216*
			(0.0107)
difflead1bothgatt	0.108***	0.104***	0.0957***
	(0.0128)	(0.0130)	(0.0131)
diffcomcur	0.142***	0.241***	0.316***
	(0.0167)	(0.0258)	(0.0357)
difflag1comcur		0.0886***	0.159***
		(0.0175)	(0.0277)
difflag2comcur			0.123***
			(0.0196)
difflead1comcur	0.134***	0.136***	0.137**
	(0.0272)	(0.0381)	(0.0482)
N	1731210	1329371	1122540
R^2	0.107	0.115	0.123
TCE	93%	249%	450%

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In order to check whether this pre-treatment container effect is an existing trend, we could introduce a second lead treatment variable, i.e. $container_{ij,t+2}$ to see whether we pick up a similar effect for the 2nd lead as the 1st lead. The rationale behind it is simple. If we have a trend in the data, then the 1st and 2nd lead variables should be both positive, significant, and close to each other in magnitude.

In tables 7.3 and 7.4, we introduce the 2nd lead containerisation term in the estimation equation at the 1- and 4-digit product levels respectively. In all estimations in the two tables, the coefficients of both the first and second lead variables are positive and approximately of the same magnitude[3]. This result confirms that the lead effect picked up in the estimations in tables 1 and 2 may indeed be a pre-existing trend in trade.

With respect to the container effects after introducing the 2nd trend treatment variable, we don't notice major changes in the estimated TCE's compared to the first two estimation tables. This is also the case for the other policy variables treatment effects.

Table 7.3: Checking for Trend through 2nd lag; 1-digit SITC product level

	(1) difflnvalue	(2) difflnvalue	(3) difflnvalue
diffcont_ij	0.624***	0.905***	0.913***
	(0.0221)	(0.0267)	(0.0337)
difflag1		0.396***	0.363***
		(0.0216)	(0.0300)
difflag2			0.0127
			(0.0261)
difflead1	0.252***	0.362***	0.350***
	(0.0255)	(0.0279)	(0.0307)
difflead2	0.229***	0.291***	0.271***
	(0.0290)	(0.0316)	(0.0334)
diffrta	0.267***	0.262***	0.278***
	(0.0399)	(0.0402)	(0.0418)
difflag1rta		0.0744	0.0858*
		(0.0407)	(0.0414)
difflag2rta			0.156**
			(0.0527)
difflead1rta	0.0957*	0.0465	0.127*
	(0.0413)	(0.0426)	(0.0502)
diffbothgatt	0.181***	0.213***	0.205***
	(0.0280)	(0.0313)	(0.0321)
difflag1bothgatt		0.103***	0.0795**
		(0.0259)	(0.0292)
difflag2bothgatt			-0.0504
			(0.0282)
difflead1bothgatt	-0.0844*	-0.0841*	-0.0913*
	(0.0375)	(0.0374)	(0.0376)
diffcomcur	0.197***	0.153	0.354**
	(0.0582)	(0.0890)	(0.130)
difflag1comcur		0.140*	0.0787
		(0.0574)	(0.0919)
difflag2comcur			0.0744
			(0.0636)
difflead1comcur	0.0757	0.135	0.107
	(0.0966)	(0.152)	(0.188)
N	166524	153936	141348
R^2	0.136	0.140	0.144
TCE	87%	196%	193%

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[3]Testing the null that the two coefficients are statistically equal leads to accepting the null in column 1 table 7.3. We also accept the null at the 10% significance level in column 1 table 7.4. We reject the null in all other columns

Table 7.4: Checking for Trend through 2nd lag; 4-digit SITC product level

	(1) difflnvalue	(2) difflnvalue	(3) difflnvalue
diffcont_ij	0.591^{***}	0.999^{***}	1.372^{***}
	(0.00788)	(0.0105)	(0.0140)
difflag1		0.571^{***}	0.865^{***}
		(0.00771)	(0.0116)
difflag2			0.437^{***}
			(0.00964)
difflead1	0.235^{***}	0.300^{***}	0.366^{***}
	(0.00923)	(0.0102)	(0.0111)
difflead2	0.218^{***}	0.265^{***}	0.307^{***}
	(0.0104)	(0.0115)	(0.0121)
diffrta	0.317^{***}	0.331^{***}	0.330^{***}
	(0.00969)	(0.0100)	(0.0110)
difflag1rta		0.165^{***}	0.170^{***}
		(0.0102)	(0.0108)
difflag2rta			0.127^{***}
			(0.0137)
difflead1rta	-0.0327^{**}	0.000422	0.0516^{***}
	(0.00996)	(0.0108)	(0.0150)
diffbothgatt	0.316^{***}	0.368^{***}	0.321^{***}
	(0.0113)	(0.0130)	(0.0137)
difflag1bothgatt		0.140^{***}	0.112^{***}
		(0.00982)	(0.0116)
difflag2bothgatt			-0.0142
			(0.0109)
difflead1bothgatt	0.110^{***}	0.113^{***}	0.106^{***}
	(0.0138)	(0.0138)	(0.0138)
diffcomcur	0.176^{***}	0.231^{***}	0.287^{***}
	(0.0176)	(0.0259)	(0.0362)
difflag1comcur		0.0856^{***}	0.136^{***}
		(0.0175)	(0.0276)
difflag2comcur			0.101^{***}
			(0.0194)
difflead1comcur	0.154^{***}	0.139^{***}	0.116^{*}
	(0.0273)	(0.0382)	(0.0484)
N	1467883	1261047	1054216
R^2	0.111	0.118	0.127
TCE	81%	249%	487%

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7.4 Testing for Endogeneity in North-North Trade

In the previous sections, we estimate a relatively small but positive and statistically significant first-lead effect from containerisation. As mentioned above, the lead effect could be the product of a pre-existing trend, a pre-containerisation effect, or weak endogeneity. We tested for a pre-existing trend in the previous section. If the coefficient of the lead containerisation variable is not capturing pre-containerisation effects, then it could mean that we could have weak endogeneity. We use the data and the narrative to check whether our specification suffers from weak exogeneity.

We argued above that sources of endogeneity are omitted variable bias, simultaneity bias and/or measurement error. We have dealt with possible omitted variable by first-differencing the data and including importer- and exporter-time as well as product-time FE. Simultaneity bias is unlikely since the dependent variable is 4-digit product trade flow between countries i and j whereas the technology variable is ij specific. Also, it is perhaps more true that countries that trade a lot are likely to self-select into FTAs. Lastly, potential endogeneity may be caused by measurement errors in the container variable.

The analysis in this section is driven by the narrative. The narrative and the container data tells us that North countries were first to containerise. In these countries, containerisation started in port and was introduced on rail almost concurrently (chapter 4). Also our container measure is likely to capture the intermodal effects of using containers on the roads as well. This means that measurement error in the container variables are minimal for the sample of North countries.

Our containerisation measure depends on the bilateral adoption of containerisation on any specific trade route. Some countries containerise before others. We know already that many ships had onboard cranes especially in the early years to enable containers to be handled in unequipped ports. Also, the bigger ports in some countries served as centres for hub and spoke systems in which containers made their way to the hub and then transferred onto lighters and barges to smaller ports in more peripheral countries. These effects are likely to be captured by the lead container variable.

Our data allows for an experiment that is driven by the narrative to test whether the lead effect we estimate is indeed a pre-container effect. We know that a pre-container effect emanating from a unilateral adoption of the technology in North-North trade should not be there since these countries adopted the technology in the early years of containerisation.

Therefore, the narrative suggests that we should not capture a significant lead variable coefficient for North-North trade. In this section, we examine this claim in the sample of North-North containerisable trade at the 4-digit product levels. This exercise serves as a test for endogeneity. If we have a causal relationship between containerisation and the trade flows, then we do not expect to observe a lead effect in North-North trade. We restrict our sample to North-North containerisable trade flows and run the same regression as in table 7.2.

The results in table 7.5 confirm largely that we don't pick up a lead container effect for North-North trade. In columns 2 and 3 where we include lagged effects, the lead container variable is very small and insignificant.

This experiment suggests that our estimations of the cumulative effects of containerisation on North-North containerisable trade don't suffer from endogeneity. We can therefore be more confident about making a causal statement about the effects of containerisation on this trade. The regressions also suggest that the results in tables 7.1

and 7.2 are contaminated by unilateral adoption of containerisation and measurement error. The results of the regressions in the two tables are therefore only suggestive and we cannot be as confident about making causal statements for overall containerisable trade.

With regards to magnitude of effects of containerisation on North-North trade, compared to the sample average treatment effects in table 7.2, the estimates suggest that North-North containerisable trade was less affected by containerisation on average than the entire sample even after accounting for lagged effects. This result is consistent with what we found in the previous chapter for the contemporaneous effects on North-North trade. We estimate a TCE on North-North containerisable trade of 50% in column 1, 152% in column 2, and 381% in column 3. This is compared with 450% for the TTE of containerisation 10 to 15 years later for the entire sample.

As for the effects of the other policy variables on North-North containerisable trade, we find that the contemporaneous and lagged effects of FTAs on North North in table 7.5 is very close to the estimates of the full sample in table 7.2. This is not the case for GATT membership. The results suggest that GATT membership has a positive and strong TTE on North-North containerisable trade which is similar in magnitude to table 7.2 in column 2 (1st lag) but much higher in column 3 (1st and 2nd lag). This is not the case for column 1 (no lags) where the estimated coefficient of the contemporaneous policy variable is very small and insignificant. In columns 2 and 3, we estimate a TTE for GATT membership of around 51% and 159% respectively. Having said that, we should not give much weight to this result since most North countries became GATT members before 1962 and the only three countries that joined the GATT in our sample period are Iceland (1968), Switzerland (1966) and Spain (1963). Finally, with regards to common currencies, the number of common currencies between North countries in our sample is very limited. These are: UK-Ireland (until 1978), New Zealand-UK (until 1966), and New Zealand-Ireland (until 1966). TTE of common currency on North North containerisable trade is between 20% (no lags) and 70% (with 2 lags).

The cumulative effect of containerisation is therefore multiple times the effect of the individual policy variables, around 2-4 times larger in magnitude.

To summarise, by restricting the sample to North North trade, we do not estimate a significant coefficient for the 1st lead container variable. This serves as a test of strict exogeneity. We do not expect a pre-container effect from the narrative and the data descriptives. This is similarly confirmed by the result. As a result, we are confident that we estimate a causal effect for containerisation on North-North containerisable trade. With regards to the magnitude of this effect, the estimated TCE on North North trade is less than the estimated effect of the container in the entire sample. The estimated cumulative container effect remains multiple times the cumulative effects of FTAs, GATT membership, and common currency in the sample of North North trade - around 2-4 times as large. We turn to North-South and South-South containerisable trade in the next section.

Table 7.5: Introducing lags and leads of full containerisation: First differenced model (by ijk); 4-digit SITC product level; North North containerisable trade

	(1) difflnvalue	(2) difflnvalue	(3) difflnvalue
diffcont_ij	0.403***	0.623***	0.983***
	(0.0135)	(0.0230)	(0.0618)
difflag1		0.507***	0.831***
		(0.0131)	(0.0220)
difflag2			0.613***
			(0.0148)
difflead1	0.349***	0.110	0.0989
	(0.0263)	(0.0801)	(0.0757)
diffrta	0.405***	0.372***	0.363***
	(0.00970)	(0.0101)	(0.0106)
difflag1rta		0.137***	0.147***
		(0.0102)	(0.0102)
difflag2rta			0.176***
			(0.0121)
difflead1rta	-0.0509***	-0.0259*	0.127***
	(0.00993)	(0.0106)	(0.0163)
diffbothgatt	0.0268	0.252***	0.541***
	(0.0311)	(0.0409)	(0.0579)
difflag1bothgatt		0.200***	0.477***
		(0.0280)	(0.0439)
difflag2bothgatt			0.228***
			(0.0281)
difflead1bothgatt	0.369	0.312	0.227
	(0.215)	(0.212)	(0.199)
diffcomcur	0.182***	0.0422	0.136**
	(0.0423)	(0.0520)	(0.0517)
difflag1comcur		0.295***	0.268***
		(0.0450)	(0.0571)
difflag2comcur			0.226***
			(0.0442)
difflead1comcur	0.205***	0.243***	0.204**
	(0.0542)	(0.0550)	(0.0625)
N	481174	346690	263253
R^2	0.117	0.128	0.154
TCE	50%	152%	381%

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7.5 Lagged Container effects in North-South and South-South Trade

After investigating the lead and lagged effects of containerisation on North-North containerisable trade, we move to investigate the same effects on North-South and South-South trade. Similar to the previous estimations in this chapter, introducing the lead and lagged independent variables allows us to investigate whether the effects of the container are felt some years after bilateral adoption and serve as a test for endogeneity.

In table 7.6, we replicate the regressions in table 7.2 for North-South containerisable trade while in table 7.7, we look at South-South containerisable trade. We consider the 4-digit product disaggregate level.

The results in table 7.6 suggest that North-South containerisable trade was affected by containerisation more than the average effect in the entire sample and North-North trade. We estimate large and significant coefficients for the contemporaneous containerisation variable in all three regressions. Containerisation effects are also persistent 5 and 10 years to 15 years later based on these regressions. TCE effects are very large indeed. Trade increases 1.5- to 12-fold between North and South due to containerisation. This result supports the finding in chapter 6 that North South containerisable trade benefited the most from containerisation. In chapter 6, we argue that this result supports the claim that containerisation allowed and fostered offshoring and the fragmentation of the production process which resulted in changes in the composition of trade between North and South. South countries have become major exporters of containerisables especially manufactures and hi-tech parts and components.

Similar to what we find in the regressions that pertain to the entire sample, the coefficients of the lead treatment variable in the estimations for North-South trade are significant and positive. The results from the North-North and the North-South regressions suggest that the latter results may be contaminated with unilateral containerisation or the use of containers on trucks. Having said that, the coefficients of the lead variables are very small compared to the contemporaneous effects indicating that any effects from unilateral containerisation are not large. While one may say that the results found here provide evidence that containerisation had large effects on North-South trade, one cannot be as confident here about making causal statements as we did for North-North trade.

With regards to the other policy variables, there is evidence that FTAs actually lead to less trade in the North-South sample. The caveat here is that the number of FTAs in this sample is three [4]. The coefficients of the 1st lagged FTA variable in columns 2 and 3 are negative and significant and so is the coefficient of 2nd lagged FTA variable in column 3.

[4] The only FTAs between North and South countries in the years 1962-1990 are EC-Algeria, EC-Syria, and Israel-USA

GATT membership matters a lot in North-South containerisable trade. Bilateral GATT membership has a strong contemporaneous effect on trade and this effect persists 10-15 years later. The coefficients of the contemporaneous and lagged GATT variables are positive and significant in all three regressions. TTE for GATT membership ranges between 67% and 147%.

Similarly, there is evidence that common currency stimulates North-South containerisable trade. We estimate positive and significant coefficients for the contemporaneous and lagged container variables. TTE for common currency ranges between 20% with no lags and 78% with 2 lags (10-15 years later).

Table 7.6: Introducing lags and leads of full containerisation: First Differenced Model (by ijk); 4-digit SITC product level; North South containerisable trade

	(1) difflnvalue	(2) difflnvalue	(3) difflnvalue
diffcont_ij	0.952***	1.624***	2.206***
	(0.0106)	(0.0162)	(0.0225)
difflag1		0.864***	1.408***
		(0.0122)	(0.0191)
difflag2			0.628***
			(0.0154)
difflead1	0.136***	0.132***	0.120***
	(0.0102)	(0.0115)	(0.0121)
diffrta	0.0783*	0.0388	0.0222
	(0.0390)	(0.0397)	(0.0404)
difflag1rta		-0.304***	-0.302***
		(0.0463)	(0.0474)
difflag2rta			-0.293***
			(0.0774)
difflead1rta	0.0612	0.0851	0.206***
	(0.0430)	(0.0440)	(0.0451)
diffbothgatt	0.512***	0.613***	0.624***
	(0.0154)	(0.0205)	(0.0251)
difflag1bothgatt		0.292***	0.362***
		(0.0153)	(0.0211)
difflag2bothgatt			0.156***
			(0.0178)
difflead1bothgatt	0.115***	0.125***	0.126***
	(0.0181)	(0.0184)	(0.0185)
diffcomcur	0.185***	0.374***	0.463***
	(0.0209)	(0.0325)	(0.0490)
difflag1comcur		0.0498*	0.106**
		(0.0215)	(0.0341)
difflag2comcur			0.0765**
			(0.0238)
difflead1comcur	0.158***	0.0810	0.0775
	(0.0341)	(0.0524)	(0.0662)
N	1028251	810888	704113
R^2	0.122	0.132	0.139
TCE	159%	545%	1200%

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In table 7.7, we restrict the sample to South-South trade. Containerisation had a sizeable effect on South South containerisable trade albeit much less than the effects on North South. The cumulative effect of the container ranges between 105% with no lags and 271% with 2 lags, i.e. 10 to 15 years after containerisation. The cumulative effect of containerisation of 271% on containerisable trade of South South trade is smaller than the cumulative effect estimate in the total sample in table 7.2 (450%), North-North regressions in table 7.5, and North-South regressions in table 7.6.

Turning to the lead container variable, the coefficients are positive and significant as well unlike the North-North estimations. Here too, this suggests that the estimations may be contaminated by unilateral containerisation. The lead coefficients are much smaller than the contemporaneous variable coefficients however.

With regards to the effect of signing an FTA on the trade of South South trade, we notice two main things. The first is that unlike the effects of FTAs on North South trade, there is some evidence that FTAs in our estimations have a positive effect on South South containerisable trade by looking at the contemporaneous and lagged coefficients. The second is that the effects of FTAs in these estimations suffer from severe endogeneity. In fact, if anything, the magnitude of the coefficients of the lead FTA variables suggest that causality runs in the opposite direction. This is quite interesting because this suggests that the likelihood of signing an FTA is very much determined by the volume of trade. This rather strong feedback from FTAs is not found in this magnitude in tables 1 and 2 or in North North and North South regressions.

There is evidence that bilateral GATT membership has an effect on South South trade. TTE of GATT memberships on South-South containerisable trade range from 29% in column 1 with no lags to 32% with 1 lag to 15% with 2 lags. However, here too, we estimate a large pre-GATT effect relative to the contemporaneous effect.

We estimate negative coefficients for some of the contemporaneous and lagged common currency terms. We need to be careful however about how to interpret these coefficients. Most currency unions in the sample of South South trade in our time period were linked to colonialism. For example, many former British colonies shared a common currency which is the colonial British pound until they gained independence. Also, some countries split from a single state. For instance, Pakistan and Bangladesh split in 1971. So in our sample, there are no common currency unions forming but rather disintegrating. In table 7.7, The coefficients of the level common currency variable and its 1st lag are negative and statistically significant at the 5% and 1% levels respectively in column 2. In column 3, we estimate a negative and statistically significant coefficient for the 1st lagged term. To interpret this, trade is reduced by the disintegration of common currency unions, which is something expected.

In conclusion, we estimate positive lead variable coefficients for containerisation which makes us less confident about making causal statements about the effects of

Table 7.7: Introducing lags and leads of full containerisation: First Differenced Model (by ijk); 4-digit Industries; South South containerisable trade

	(1) difflnvalue	(2) difflnvalue	(3) difflnvalue
diffcont_ij	0.718***	1.009***	1.104***
	(0.0173)	(0.0236)	(0.0299)
difflag1		0.436***	0.488***
		(0.0225)	(0.0307)
difflag2			0.0644*
			(0.0307)
difflead1	0.248***	0.301***	0.309***
	(0.0180)	(0.0196)	(0.0206)
diffrta	0.180**	0.266**	0.407*
	(0.0679)	(0.0881)	(0.164)
difflag1rta		0.374***	0.376***
		(0.0777)	(0.0904)
difflag2rta			-0.0972
			(0.392)
difflead1rta	0.0664	1.207***	1.232***
	(0.103)	(0.302)	(0.303)
diffbothgatt	0.252***	0.276***	0.261***
	(0.0207)	(0.0240)	(0.0256)
difflag1bothgatt		0.0303	0.0218
		(0.0254)	(0.0282)
difflag2bothgatt			-0.156***
			(0.0356)
difflead1bothgatt	0.118***	0.133***	0.134***
	(0.0255)	(0.0266)	(0.0275)
diffcomcur	-0.121*	-0.321**	-0.0626
	(0.0585)	(0.115)	(0.233)
difflag1comcur		-0.218***	-0.371**
		(0.0627)	(0.125)
difflag2comcur			-0.0817
			(0.0755)
difflead1comcur	-0.313*	0.206	0.771
	(0.149)	(0.422)	(0.538)
N	221785	171793	155174
R^2	0.143	0.152	0.158
TCE	105%	229%	271%

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

containerisation on North-South and South-South container trade. The size of these coefficients is very small however compared to the contemporaneous variable coefficients which is suggestive of the direction of causality from containerisation to trade volumes. The estimations of North-North trade suggest that the lead coefficients in the North-South and South-South regressions are capturing unilateral containerisation and the intermodal use of containers on roads.

If we want to comment on the regressions in this section, the results suggest that containerisation affected North-South containerisable trade the most- more than North-North and South-South containerisable trade. TCE estimated on North-South containerisable trade are very large and are estimated around 12-fold 10 to 15 years after the bilateral adoption of the technology. This supports the claim that containerisation aided if not allowed the fragmentation of the production process and the expansion of North South trade in which South countries became major suppliers of manufactures and containerisables to North countries. The TTE of containerisation on North-South containerisable trade are at least 10 times the TTE of GATT membership and common currency. Similarly, containerisation is estimated to have affected South-South containerisable trade albeit to a much lesser extend. TCE is estimated around 270% 10-15 years after adoption.

7.6 Plotting Treated Series

After we have estimated the total treatment effects for containerisation on containerisable trade, we plot the treated trade series by treatment year. This gives an indication on how trade developed following treatment - a bilateral adoption of the new technology. In constructing the series, we aggregate trade observations that are treated by treatment year. We then normalise the value of trade at the time of treatment to 100 to construct indices and trace the indices.

In figure 6.1, we notice that the series that were treated in 1967 and 1972 follow similar paths in which their slopes become steeper 2 or 3 periods after treatment. From the diagram, it seems that the series treated in 1977, 1982, and 1987 were affected less than the first series in the time periods after containerisation available to us.

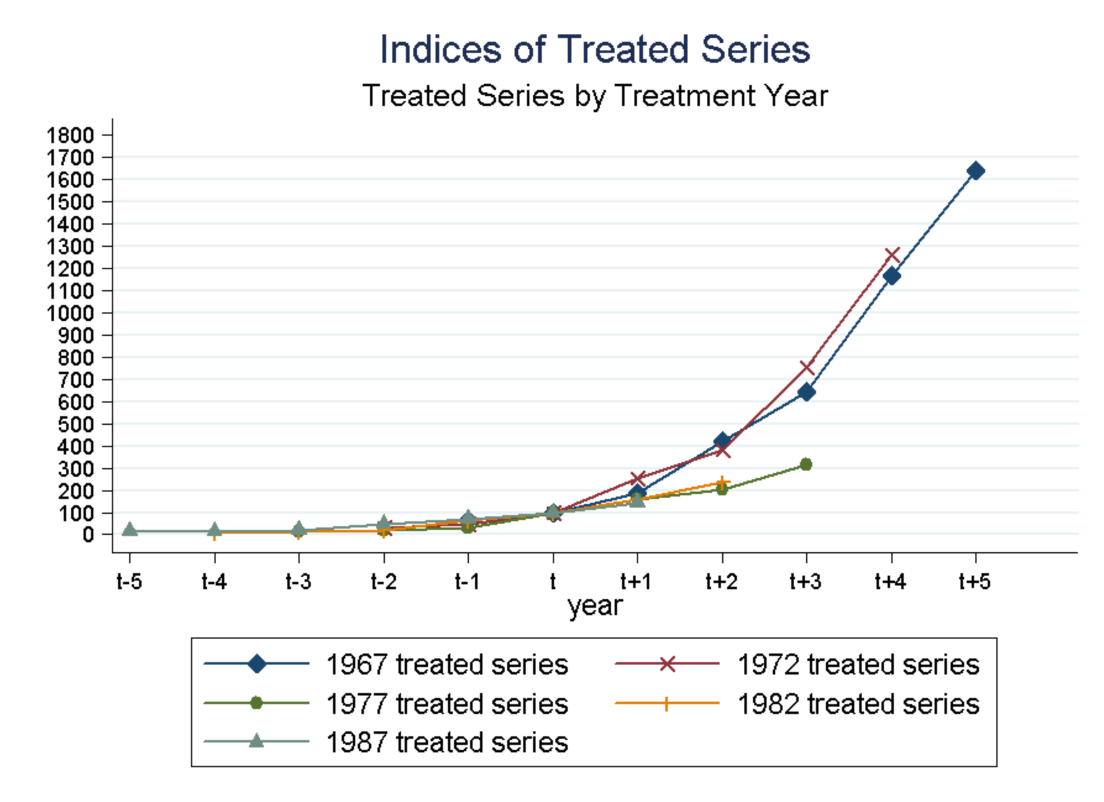

Figure 7.1: Indices of Treated Trade Series

7.7 Chapter Conclusion

Are the effects of containerisation only contemporaneous or where they felt many years later?

Our treatment specification from the previous chapter provides us with the opportunity to introduce lagged and lead terms of the control variables. There are many advantages to doing so. We are able solve for omitted variable bias if the error term is correlated with lagged independent variables. We are able to test the claim that containerisation had long-lasting effects on trade. Finally, we follow Wooldridge (2010) and use the lead terms to test for strict exogeneity in the effects of containerisation.

The estimates suggest that containerisation does not only have contemporaneous effects on containerisable trade in the entire sample. Indeed, the effects of containerisation can be felt 10 to 15 years later. We estimate a total container effect of 165% to 450% over a period of 10-15 years depending on the level of product disaggregate level. This effect is 6 to 10 times the TTE of the policy variables FTAs, GATT membership, and common currency. We also estimate a positive and significant coefficient for the lead container variable, the magnitude being much smaller than level container variable. We argue that this lead effect can be either a pre-existing trend, a pre-container effect, or a sign of weak endogeneity.

We test for a pre-existing trend by introducing a second lead container variable and we find that the coefficients thereof are very close to the 1st lead variable coefficients which suggests a pre-existing trend.

We argue that if the first lead variable is picking up a pre-container effect, then it is likely to be the result of unilateral adoption of the container technology or perhaps the development of the hub-and-spoke system. The source of any endogeneity is likely to be measurement error because our container measure does not capture the use of containers over the road. The narrative suggests that both the pre-container effect as well as any measurement error are most likely to be non-existent for North countries. We investigate this by restricting the sample to North-North countries. We find indeed that the coefficient of the lead container variable is statistically insignificant in the sample of North-North countries just as one might expect from the narrative. As suggested by Wooldridge (2010), this is evidence of strict exogeneity and we can be confident about making causal statements concerning North-North trade. We estimate that containerisation had a cumulative effect of around 380% on North-North containerisable trade over a period of 10-15 years.

Unlike North countries, a pre-container effect as well as measurement error may be present in the sample of South countries. This is confirmed when we estimate positive and statistically significant container lead coefficients in North-South and South-South containerisable trade regressions. The coefficients thereof are however small relative to the level variables. Therefore, the results for the sample of North-South and South-South trade are suggestive of a causal effect but we cannot be as confident about making causal statements. Nevertheless, the regressions suggest that North-South containerisable trade is affected the most by containerisation, followed by North-North and then South-South containerisable trade. In all cases, the cumulative treatment effects of containerisation are multiples of the effects of the individual policy variables - between 2 and 10 times as large. The large effects estimated for North-South trade can be explained by the change in the composition of trade in which a clear move towards containerisable products can be seen as highlighted in chapter 4.

Chapter 8

Conclusion

This thesis is the first attempt to explore the effects of the container on world trade in economics. Although there is ample anecdotal evidence on the effects of containerisation on world trade (mainly in the business literature), quantitative and econometric evidence on the effects of containerisation remains lacking. Besides being the first attempt to quantify the effects of containerisation on international trade, this thesis makes other contributions to the literature. We collect data from a specialist business publication on the adoption of the containers between 1966 and 1983 across the world. We construct a qualitative measure of containerisation that reflects the cross-sectional and time-series variation in the adoption of the new technology. This is the first measure of containerisation in the economics literature as far as we know. Also, the nature of the study and empirical specifications allows for a "horse race" between technological change and policy in international trade. The comparison between the two remains a disputed issue as highlighted by Krugman (1995).

Data on containerisation is extremely scarce. We use data available in Containerisation International Yearbook, a specialist business publication. The container measure that we construct makes use of information on the adoption of containerisation in ports and rail. We know that there is a third mode of transport that containerisation affected which is road. Our data does not include roads. This places limitations on our container measures and therefore measurement error may be introduced in the data which might produce some bias in the results. We deal with this in parts of the analysis by focusing on subsamples where measurement error is minimised. We make use of the narrative in driving our analysis in this respect. Beside data on containerisation, we make use of a scientific containerisability classification from 1968 that classifies products as fit for shipping in containers or not. Using this classification and the commodity trade data set of Feenstra et al. (2005), we explore some interesting trends and patterns on the trade data. We find that before containerisation, containerisable trade was dominated by basic commodities such as coffee and cotton. After containerisation was largely completed, the top 20 traded containerisable products are all manufactures, the majority of which are high-tech manufactures and electronics. When isolating North-South trade, similar patterns are found. For instance, South countries exported mainly basic commodities to North countries such as coffee, copper, tea, cocoa, and copra in 1962. In 1990, the top containerisable traded products exported by South countries are footwear and electronic micro-circuits. There is therefore a clear shift in the composition of trade towards advanced and hi-tech manufactures after containerisation was largely adopted worldwide. The business literature is of the opinion that this shift of the South countries towards becoming major suppliers of manufactures to North countries was enabled by the fragmentation of the production process, which in-turn was enabled by the container.

In estimating the effects of containerisation on world trade, we start our investigation from the gravity model in line with the literature. We initially consider bilateral aggregate trade outcomes in chapter 5. We attempt different FE specification to pin down how containerisation should be modelled in this context. We consider annual data, 5-year intervals, port containerisation, port and rail containerisation, a reduced gravity equation as well as a first-differenced model. We also address some econometric problems that are likely to feature in the estimations such as omitted variable bias and endogeneity. When considering annual data and a traditional gravity equation with country-pair and year effects, we estimate an effect for port containerisation of around 22% on aggregate trade flows when both the origin and destination countries adopt the technology in ports in addition to an annual growth rate of around 3% (trend). We also estimate an additional effect for containerisation by rail on the aggregate trade flows.

The derivation of a structural gravity equation from microeconomic foundations showed that estimations of the 'traditional' gravity equation suffer from omitted variable bias because it ignored multilateral resistances. We control for multilateral resistances by estimating a 'reduced' form gravity equation with importer and exporter-time FE. Containerisation is now measured as a bilateral adoption of the technology and we choose 5-year intervals to allow the regressions to run and time for adjustment. We also estimate a first-differenced model as proposed by Wooldridge (2010). We argue that the first-differenced model is the least restrictive one. Estimating the reduced gravity equation as well as the first-differenced model return no results for containerisation on aggregate trade flows. We find however that full containerisation (port and rail) had a strong positive effect on the trade in manufactures between 14% and 22%. The results from the aggregate trade flow regressions may be explained by the fact that not all products are moved in containers. Also, containerisation may have affected products differently and aggregation may introduce aggregation bias as suggested by Anderson (2011). We therefore explore commodity trade flows in chapter 6.

It is perhaps intuitive that not all products are moved in containers. This may help explain the weak results reached when we consider aggregate trade flows. We use the product containerisability classification introduced in chapter 4 to identify products that are moved in containers in 1968. We can be confident that products that are classified as containerisable in 1968 can be moved in containers at the start of the process and remain so after. We cannot be sure about products that are classified as non-containerisable however. This is because this group may contain products that may become containerisable or products whose trade may be affected by containerisation owing to their parts/intermediate products which are containerisable. As a result, causal statements are cleaner for products that are classified as containerisable in 1968. Using the product level trade flows, we identify the effects of containerisation in a treatment type equation in which the dependent variable is the 1-digit or 4-digit SITC product trade flows. The identification of the container effects comes from the treatment group which is the containerisable products trade between two containerising countries. We first-difference the estimation equation and include importer- and exporter-time as well as product FE to deal with omitted variables which may bias the estimation. The estimation equation provides us with a way to compare between the effects of the technology variables and the policy variables: FTAs, GATT membership, and common currencies. Estimating the treatment first-differenced equation returns strong results for the container treatment variable. The treatment effect is estimated to be around 90% for full containerisation (port and rail) and 70% for port containerisation. The results are robust to the product disaggregation level. The relatively large effect for the container is around twice the individual effect of FTAs and GATT membership on containerisable trade and up to six times the effect of common currency. We also deal with potential bias from measurement error by considering North-North trade. The narrative suggests that measurement error is likely to be minimal in the sample of North countries. Therefore, a causal relationship is clearer for North-North containerisable trade. We estimate an effect of full containerisation on this trade of around 28%. The effects are found to be much higher for North-South and South-South trade, 160% and 100% respectively. The result is suggestive but a causal statement is less clear in the case of the latter sub-samples mainly because of potential measurement error.

Finally, in chapter 7, we dealt with an obvious extension which is the dynamic effects of containerisation. We do so by introducing lagged and lead terms of the control variables. There are many advantages to doing so. We are able solve for omitted variable bias if the error term is correlated with lagged independent variables and test the claim that containerisation had long-lasting effects on trade. Also we can introduce a lead treatment variable which serves as a test for strict exogeneity in the effects of containerisation as suggested by Wooldridge (2010).

The estimates suggest that containerisation does not only have contemporaneous effects on containerisable trade in the entire sample. Indeed, the effects of containerisation can be felt 10 to 15 years later. We estimate a cumulative container treatment effect of 165% to 450% over a period of 10-15 years depending on the level of product disaggregate level. This effect is 6 to 10 times the cumulative effects of the policy variables FTAs, GATT membership, and common currency. We also estimate a positive and significant coefficient for the lead container variable, the magnitude being much smaller than level container variable. The lead effect can be a pre-existing trend, a pre-container effect, or could indicate weak endogeneity. We find evidence that a pre-existing trend may be present in the data. The narrative provides us a way to test whether this lead effects constitutes a pre-container effect. A pre-container effect is likely to be the result of unilateral adoption of the container technology or perhaps the development of the hub-and-spoke system. Also any source of endogeneity is likely to be coming from measurement error because our container measure does not capture the use of containers over the road. The narrative suggests that both the pre-container effect as well as any measurement error are most likely to be minimal for North countries. We investigate this by restricting the sample to North-North countries. We find indeed that the coefficient of the lead container variable is statistically insignificant in the sample of North-North countries just as one might expect from the narrative. As suggested by Wooldridge (2010), this is evidence of strict exogeneity and we can be confident about making causal statements concerning North-North trade. This also suggests that the lead effect estimated in the entire sample regressions may be a combination of a trend, a pre-container effect and measurement error. We estimate that containerisation had a cumulative effect of around 380% on North-North containerisable trade over a period of 10-15 years.

Looking at cumulative treatment effects in North-South and South-South countries suggest that North-South containerisable trade is affected the most by containerisation, followed by North-North and then South-South containerisable trade. In all cases, the cumulative treatment effects of containerisation are multiples of the effects of the individual policy variables - between 2 and 10 times as large depending on the policy variable. The large effects estimated for North-South trade can be explained by the change in the composition of trade in which a clear move towards containerisable products can be seen as highlighted in chapter 4. However, we estimate positive and statistically significant container lead coefficients in North-South and South-South containerisable trade regressions. The coefficients are however small relative to the level variables. Therefore, the results for the sample of North-South and South-South trade are suggestive of a causal effect but we cannot be as confident about making causal statements as in North-North trade.

It is a known fact that the composition of trade between North and South countries has changed radically since the 1960s and 1970s. As we already mentioned, trade between the two groups of countries was mainly basic commodities in 1962 but becomes dominated by manufactures and hi-tech products in 1990. The business literature claims that this was made possible by containerisation. In chapters 6 and 7, we found evidence that suggests that containerisation affected North-South trade the most. This suggests that containerisation may have led to the creation of trade. Future research should therefore examine in depth this question by exploring the effects of containerisation on the extensive and intensive margins of trade.

Future research should also look at the welfare effects of containerisation because the narrative suggests substantial welfare consequences. We only brushed on this in chapter 2 in this thesis. We know that containerisation led to the destruction of the profession of dockers. Entire communities were affected by this such as East London. Also, manufacturing jobs were affected because containerisation removed the need for plants to locate near the port. Any research into the welfare effects of containerisation is very helpful to understand how policy should deal with technological changes that are likely to have consequences for certain sections of the community.

Other research that looks very promising is the issue of containerisation and just-in-time manufacturing. It is well-known that the just-in-time manufacturing model depends heavily on the reliability of container shipping. This is highly suggestive of the relationship of containerisation and just-in-time manufacturing which in-turn had major effects on the world economy and consumer welfare in the US and Europe.

One of the messages that one can take from this thesis is surely that the issue of containerisation and trade is more complicated than just sticking a dummy into a gravity model and requires an understanding of the historical narrative. We see this clearly in this thesis. More work is obviously needed to help understand the effects of a major technological change such as containerisation. This is the first research into the effects of containerisation. It is certainly not the last word on containerisation and world trade.

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Appendix A

Data and Constructing the Container Variable

Table A.1: Countries in the entire sample (157 countries)

Afghanistan	Dominican Republic	Jordan	Qatar
Albania	Ecuador	Kenya	Romania
Algeria	Egypt	Kiribati	Rwanda
Angola	El Salvador	Korea Democratic People's Republic	Samoa
Argentina	Equatorial Guinea	Korea Republic	Saudi Arabia
Asia NES (Bhutan, Brunei)	Ethiopia	Kuwait	Senegal
Australia	Falkland Islands	Laos	Seychelles
Austria	Fiji	Lebanon	Sierra Leone
Bahamas	Finland	Liberia	Singapore
Bahrain	East Germany	Libya	Somalia
Bangladesh	West Germany	Madagascar	South Africa
Barbados	Fm USSR	Malawi	Spain
Belgium-Luxembourg	Fm Yugoslavia	Malaysia	Sri Lanka
Belize	French Overseas Departments	Mali	St.Helena
Benin	French Guiana	Malta	St. Kitts , Nevis -Anguilla
Bermuda	France, Monaco	Mauritania	Saint Pierre and Miquelon
Bolivia	Gabon	Mauritius	Sudan
Brazil	Gambia	Mexico	Suriname
Bulgaria	Ghana	Mongolia	Sweden
Burkina Faso	Gibraltar	Morocco	Switzerland-Liechtenstein
Burundi	Greece	Mozambique	Syria
Cambodia	Greenland	Myanmar	Taiwan
Cameroon	Guadeloupe	Nepal	Tanzania
Canada	Guatemala	Netherlands Antilles, Aruba	Thailand
Central African Republic	Guinea	Netherlands	Togo
Chad	Guinea Bissau	New Caledonia	Trinidad Tobago
Chile	Guyana	New Zealand	Tunisia
China	Haiti	Nicaragua	Turkey
Hong Kong	Honduras	Niger	Uganda
Macao	Hungary	Nigeria	UK
Colombia	Iceland	Norway	United Arab Emirates
Congo	India	Oman	Uruguay
Costa Rica	Indonesia	Pakistan	USA
Cote Divoire	Iran	Panama	Venezuela
Cuba	Iraq	Papua N. Guinea	Viet Nam
Cyprus	Ireland	Paraguay	Zambia
Czechoslovakia	Israel	Peru	Zimbabwe
Democratic Republic Congo	Italy	Philippines	
Denmark	Jamaica	Poland	
Djibouti	Japan	Portugal	

Table A.2: Countries that containerise between 1966 and 1983 (118 countries)

Algeria	Djibouti	Ireland	Nigeria	Thailand
Angola	Dominican Republic	Israel	Norway	Togo
Argentina	Ecuador	Italy	Oman	Trinidad Tobago
Australia	Egypt	Jamaica	Pakistan	Tunisia
Bahamas	El Salvador	Japan	Panama	Turkey
Bahrain	Ethiopia	Jordan	Papua N.Guinea	UK
Bangladesh	Fiji	Kenya	Peru	USA
Barbados	Finland	Kiribati	Philippines	United Arab Emirates
Belgium-Luxembourg	East Germany	Korea Republic	Poland	Uruguay
Belize	West Germany	Kuwait	Portugal	Venezuela
Benin	Fm USSR	Lebanon	Qatar	
Bermuda	Fm Yugoslavia	Liberia	Romania	
Brazil	France, Monaco	Libya	Samoa	
Asia NES (Bhutan, Brunei)	Gambia	Madagascar	Saudi Arabia	
Bulgaria	Ghana	Malaysia	Seychelles	
Cameroon	Gibraltar	Malta	Sierra Leone	
Canada	Greece	Mauritania	Singapore	
Chile	Guadeloupe	Mauritius	South Africa	
China	Guatemala	Mexico	Spain	
Hong Kong	Guinea	Morocco	Sri Lanka	
Colombia	Haiti	Mozambique	St. Helena	
Congo	Honduras	Myanmar	St. Kitts & Nevis -Anguilla	
Costa Rica	Iceland	Netherlands Antilles & Aruba	Sudan	
Cote Divoire	India	Netherlands	Sweden	
Cyprus	Indonesia	New Caledonia	Syria	
Democratic Republic Congo	Iran	New Zealand	Taiwan	
Denmark	Iraq	Nicaragua	Tanzania	

Table A.3: Non-landlocked countries in our data set that remain uncontainerised until 1990 (18 countries)

Albania
Cambodia
Macao
Cuba
Equatorial Guinea
Falkland Islands
French Overseas Departments
French Guiana
Gabon
Greenland
Guinea Bissau
Guyana
Korea Democratic People's Republic
Senegal
Somalia
Saint Pierre and Miquelon
Suriname
Viet Nam

Table A.4: Landlocked countries in our data set (21 countries)

Afghanistan
Austria
Bolivia
Burkina Faso
Burundi
Central African Republic
Chad
Czechoslovak
Hungary
Laos
Malawi
Mali
Mongolia
Nepal
Niger
Paraguay
Rwanda
Switzerland-Liechtenstein
Uganda
Zambia
Zimbabwe

Table A.5: Countries with Reported Trade Data for 1984-1990 (63 countries)

Algeria	Fm Czechoslovakia	Kuwait
Angola	Fm Fed Germany	Libya
Argentina	Fm USSR	Saudi Arabia
Australia	Fm Yugoslavia	Malaysia
Singapore	Austria	France
Mexico	Morocco	Belgium-Luxembourg
Greece	Netherlands	South Africa
Brazil	Hong Kong	New Zealand
Spain	Bulgaria	Hungary
Nigeria	Sweden	Canada
India	Norway	Switzerland
Chile	Indonesia	Oman
Thailand	China	Iran
Pakistan	Tunisia	Colombia
Ireland	Peru	Turkey
Israel	Philippines	United Kingdom
Denmark	Italy	Poland
United Arab Emirates	Dominican Republic	Japan
Portugal	USA	Ecuador
Qatar	Venezuela	Finland
Korea Republic	Romania	Vietnam

Table A.6: Countries for which containerisation and GDP data are available (127 countries)

Afghanistan	Guinea	Seychelles
Algeria	GuineaBissau	Sierra Leone
Argentina	Guyana	Singapore
Australia	Haiti	Somalia
Austria	Honduras	South Africa
Bahamas	Iceland	Spain
Bangladesh	India	Sri Lanka
Barbados	Indonesia	Saint Kitts and Nevis - Anguilla
Belgium-Luxembourg	Iran	Sudan
Belize	Iraq	Suriname
Benin	Ireland	Sweden
Bermuda	Israel	Switzerland Liechtenstein
Bolivia	Italy	Syria
Brazil	Jamaica	Taiwan
Burkina Faso	Japan	Tanzania
Burundi	Jordan	Thailand
Cambodia	Kenya	Togo
Cameroon	Korea Republic	Trinidad Tobago
Canada	Kuwait	Tunisia
Central African Republic	Liberia	Turkey
Chad	Madagascar	United Kingdom
Chile	Malawi	United States of America
China	Malaysia	Uganda
China Hong Kong	Mali	Uruguay
Colombia	Malta	Venezuela
Congo	Mauritania	Zambia
Costa Rica	Mauritius	Zimbabwe
Cote D' Ivoire	Mexico	
Cyprus	Morocco	
Czechoslovakia	Mozambique	
Democratic Republic of Congo	Myanmar	
Denmark	Nepal	
Dominican Republic	Netherlands	
Ecuador	New Zealand	
Egypt	Nicaragua	
El Salvador	Niger	
Equatorial Guinea	Nigeria	
Ethiopia	Norway	
Fiji	Oman	
Finland	Pakistan	
Former German Federal Republic	Panama	
Former Union of Soviet Socialist Republics	Papua New Guinea	
Former Yugoslavia	Paraguay	
Fr Ind O (Reunion, French South Antartic Territories, Comoros)	Peru	
France,Monaco	Philippines	
Gabon	Portugal	
Gambia	Romania	
Ghana	Rwanda	
Greece	Saudi Arabia	
Guatemala	Senegal	

Table A.7: Containerisability of products at the SITC Rev 2: Class A Suitable for Containers

Code	Good Description
035	Fish, dried, salted or in brine smoked fish
037	Fish, crustaceans and molluscs, prepared or preserved
042	Rice
046	Meal and flour of wheat and flour of meslin
047	Other cereal meals and flours
048	Cereal preparations & preparations of flour of fruits or vegetables
056	Vegetables, roots & tubers, prepared/preserved, n.e.s.
058	Fruit, preserved, and fruit preparations
061	Sugar and honey
062	Sugar confectionery and other sugar preparations
071	Coffee and coffee substitutes
072	Cocoa
073	Chocolate & other food preptions containing cocoa
074	Tea and mate
075	Spices
081	Feed.stuff for animals (not including unmilled cereals)
091	Margarine and shortening
098	Edible products and preparations n.e.s.
111	Non alcoholic beverages, n.e.s.
112	Alcoholic beverages
121	Tobacco, unmanufactured; tobacco refuse
122	Tobacco manufactured
211	Hides and skins (except furskins), raw
212	Furskins, raw (including astrakhan, caracul, etc.)
222	Oil seeds and oleaginous fruit (excluding flours and meals)
223	Oils seeds and oleaginous fruit, whole or broken (including flours and meals)
23	Crude rubber (including synthetic and reclaimed)
244	Cork, natural, raw & waste (including in blocks/sheets)
25	Pulp and waste paper
26	Textile fibres (except wool tops) and their wastes
277	Natural abrasives, n.e.s (including industrial diamonds)
291	Crude animal materials, n.e.s.
411	Animal oils and fats
423	Fixed vegetable oils, soft, crude, refined/purified
424	Other fixed vegetable oils, fluid or solid, crude
431	Animal & vegetable oils and fats, processed & waxes
53	Dyeing, tanning and colouring materials
54	Medicinal and pharmaceutical products
55	Essential oils & perfume materials; toilet polishing and cleansing preparations
58	Artificial resins, plastic materials, cellulose esters and ethers
59	Chemical materials and products, n.e.s.
61	Leather, leather manufactures, n.e.s. and dressed furskisg
62	Rubber manufactures, n.e.s.
63	Cork and wood manufactures (excluding furniture)
64	Paper, paperboard, articles of paper, paper-pulp/board
65	Textile yarn, fabrics, made-up articles, related products
664	Glass
665	Glassware
666	Pottery
667	Pearls, precious& semi-prec.stones, unwork./worked
673	Iron and steel bars, rods, angles, shapes & sections
674	Universals, plates and sheets, of iron or steel
675	Hoop & strip, of iron/steel, hot-rolled/cold-rolled
677	Iron/steel wire, wheth/not coated, but not insulated
678	Tubes, pipes and fittings, of iron or steel
679	Iron & steel castings, forgings & stampings; rough
681	Silver, platinum & oth.metals of the platinum group
682	Copper
683	Nickel
684	Aluminium
685	Lead
686	Zinc
687	Tin
689	Miscell.non-ferrous base metals employ.in metallgy
692	Metal containers for storage and transport
693	Wire products and fencing grills
694	Nails, screws, nuts, bolts etc.of iron, steel, copper
695	Tools for use in hand or in machines
696	Cutlery
697	Household equipment of base metal, n.e.s.
699	Manufactures of base metal, n.e.s.
71	Power generating machinery and equipment
723	Civil engineering and contractors plant and parts
724	Textile & leather machinery and parts
725	Paper and pulp mill mach., mach for manuf.of paper
726	Printing and bookbinding mach.and parts
727	Food processing machines and parts
728	Mach.& equipment specialized for particular ind.
73	Metalworking machinery
745	Other non-electrical mach.tools, apparatus & parts
749	Non-electric parts and accessories of machines
75	Office machines & automatic data processing equipment
76	Telecommunications & sound recording apparatus
77	Electrical machinery, apparatus & appliances n.e.s.
8	Miscellaneous manufactured articles

Table A.8: Containerisability of products at the SITC Rev 2: Class B Goods of Limited Suitability for Containers

Code	Good Description
01	Meat and meat preparations
02	Dairy products and birds' eggs
034	Fish, fresh (live or dead), chilled or frozen
036	Crustaceans and molluscs, fresh, chilled, frozen etc.
054	Vegetables, fresh, chilled, frozen/preserved; roots, tubers
057	Fruit & nuts (not including oil nuts), fresh or dried
248	Wood, simply worked, and railway sleepers of wood
271	Fertilizers, crude
287	Ores and concentrates of base metals, n.e.s.
288	Non-ferrous base metal waste and scrap, n.e.s.
289	Ores & concentrates of precious metals; waste, scrap
292	Crude vegetable materials, n.e.s.
51	Organic chemicals
52	Inorganic chemicals
671	Pig iron, spiegeleisen, sponge iron, iron or steel
691	Structures & parts of struc.; iron, steel, aluminium

Table A.9: Containerisability of products at the SITC Rev 2: Class C Goods Not Suitable For Containers

Code	Good Description
001	Live animals chiefly for food
041	Wheat (including spelt) and meslin, unmilled
043	Barley, unmilled
044	Maize, unmilled
045	Cereals, unmilled (no wheat, rice, barley or maize)
245	Fuel wood (excluding wood waste) and wood charcoal
247	Other wood in the rough or roughly squared
273	Stone, sand and gravel
274	Sulphur and unroasted iron pyrites
278	Other crude minerals
281	Iron ore and concentrates
282	Waste and scrap metal of iron or steel
3	Mineral fuels, lubricants and related materials
56	Fertilizers, manufactured
57	Explosives and pyrotechnic products
661	Lime, cement, and fabricated construction materials
662	Clay construct.materials and refractory constr.mater
663	Mineral manufactures, n.e.s
672	Ingots and other primary forms, of iron or steel
676	Rails and railway track construction material
721	Agricultural machinery and parts
722	Tractors fitted or not with power take-offs, etc.
781	Passenger motor cars, for transport of pass., goods
782	Motor vehicles for transport of goods and materials
783	Road motor vehicles, n.e.s.
785	Motorcycles, motor scooters, invalid carriages
786	Trailers and other vehicles, not motorized
791	Railway vehicles and associated equipment
792	Aircraft and associated equipment and parts
793	Ships, boats and floating structures
9	Commodities and transactions not elsewhere classified

Appendix B

Econometric Estimation of the Effects of Containerisation at the Country Level

```
. xtserial lnvalue cont_ij bothgatt rta comcur, output

Linear regression                                      Number of obs =  250779
                                                       F(  4, 15648) =   59.91
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.0007
                                                       Root MSE      =  1.2234

                                 (Std. Err. adjusted for 15649 clusters in ij)
------------------------------------------------------------------------------
             |               Robust
   D.lnvalue |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     cont_ij |
         D1. |   .1702424    .015421    11.04   0.000     .1400156    .2004693
             |
    bothgatt |
         D1. |   .0975368   .0195461     4.99   0.000     .0592243    .1358494
             |
         rta |
         D1. |   .2543591   .0269928     9.42   0.000     .2014501    .3072681
             |
      comcur |
         D1. |   .0616117   .0594406     1.04   0.300    -.0548987    .1781222
------------------------------------------------------------------------------

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,    14159) =    2827.321
           Prob > F =      0.0000
```

Figure B.1: Testing for Serial Correlation in the FE Model

Table B.1: Number of Missing Observations by Country - Bilateral Aggregate Trade Flows

Country	**# Missing Obs.**	**Country**	**# Missing Obs.**	**Country**	**# Missing Obs.**	**Country**	**# Missing Obs.**
St.Helena	4370	China MC SAR	3515	Madagascar	2632	Spain	464
Falkland Is	4351	Bahamas	3494	Kenya	2572	Austria	435
St.Pierre Mq	4192	Bolivia	3456	South Africa	2567	Switz.Liecht	298
Greenland	4118	Togo	3431	Saudi Arabia	2555	Sweden	293
Seychelles	4089	Afghanistan	3410	Fm German DR	2522	Denmark	271
Eq.Guinea	4083	Guyana	3391	Trinidad Tbg	2518	USA	242
Rwanda	4071	Uganda	3383	Nigeria	2504	Belgium-Lux	232
Samoa	4061	Mozambique	3316	Neth.Ant.Aru	2496	Fm German FR	209
Belize	4060	Dominican Rp	3310	Chile	2464	Netherlands	193
Djibouti	4047	Bangladesh	3304	Romania	2427	France,Monac	177
Gibraltar	4045	Viet Nam	3291	Tunisia	2422	Italy	168
Mongolia	3994	Korea D P Rp	3279	Fm USSR	2402	Japan	129
Lao P.Dem.R	3967	Liberia	3254	Hungary	2267	UK	103
GuineaBissau	3945	Bahrain	3247	Cote Divoire	2181		
Burundi	3942	Libya	3225	Peru	2176		
Asia NES	3937	Nicaragua	3202	Iran	2173		
Gambia	3929	Jordan	3200	Venezuela	2154		
Fr.Guiana	3925	Syria	3197	Taiwan	2132		
St.Kt-Nev-An	3878	El Salvador	3195	Poland	2056		
Kiribati	3855	Congo	3146	Egypt	2054		
Mauritania	3836	Malawi	3131	China	2042		
Zimbabwe	3783	Honduras	3121	Czechoslovak	1961		
Fiji	3781	Paraguay	3096	Colombia	1911		
Chad	3777	Gabon	3075	Indonesia	1866		
Untd Arab Em	3756	Zambia	3075	Mexico	1853		
Nepal	3725	Dem.Rp.Congo	3060	Turkey	1786		
Burkina Faso	3718	Cuba	3057	Sri Lanka	1728		
Albania	3713	Myanmar	3028	Philippines	1715		
Fr Ind O	3708	Ethiopia	3004	Israel	1576		
Papua N.Guin	3704	Jamaica	2982	Morocco	1476		
New Calednia	3697	Guatemala	2901	Malaysia	1382		
Qatar	3686	Cameroon	2883	Korea Rep.	1380		
Sierra Leone	3682	Ghana	2877	Singapore	1307		
Guinea	3674	Tanzania	2866	New Zealand	1197		
Benin	3667	Costa Rica	2859	Greece	1151		
Suriname	3666	Senegal	2832	Fm Yugoslav	1120		
Niger	3655	Kuwait	2804	Thailand	1100		
Bermuda	3622	Uruguay	2801	Argentina	1095		
Cambodia	3616	Iraq	2797	India	958		
Mauritius	3616	Panama	2770	Pakistan	954		
Somalia	3613	Cyprus	2761	Australia	838		
Cent.Afr.Rep	3600	Ecuador	2726	Portugal	786		
Angola	3588	Malta	2712	Brazil	711		
Guadeloupe	3584	Algeria	2702	Ireland	640		
Oman	3583	Lebanon	2693	Finland	630		
Haiti	3576	Bulgaria	2685	China HK SAR	532		
Barbados	3573	Sudan	2670	Norway	506		
Mali	3562	Iceland	2650	Canada	484		

Appendix C

Estimating the Effects of Containerisation at the Product Level

Table C.1: Refrigerated 4-digit SITC Products

Code	Good Description
0110	Meat, edible meat offals, fresh, chilled or frozen
0111	Meat of bovine animals, fresh, chilled or frozen
0112	Meat of sheep and goats, fresh, chilled or frozen
0113	Meat of swine, fresh, chilled or frozen
0114	Poultry, dead & edible offals except liver, fresh/frozen
0115	Meat of horses, asses, etc., fresh, chilled, frozen
0116	Edible offals of animals in headings 001.1-001.5
0118	Other fresh, chilled, frozen meat or edible offals
0120	Meat & edible offals, salted, in brine, dried/smoked
0121	Bacon, ham & other dried, salted, smoked meat/ swine
0129	Meat & edibleoffals, n.e.s. salt.in brine dried/smok.
0140	Meat & edible offals, prep./pres., fish extracts
0141	Meat extracts and meat juices; fish extracts
0142	Sausages & the like, of meat, meat offal or blood
0149	Other prepared or preserved meat or meat offals
0220	Milk and cream
0222	Milk and cream
0223	Milk & cream, fresh, not concentrated or sweetened
0224	Milk & cream, preserved, concentrated or sweetened
0230	Butter
0240	Cheese and curd
0250	Eggs and yolks, fresh, dried or otherwise preserved
0251	Eggs in shell
0252	Eggs not in shell
0340	Fish, fresh (live or dead), chilled or frozen
0341	Fish, fresh (live/dead) or chilled, excl.fillets
0342	Fish, frozen (excluding fillets)
0343	Fish fillets, fresh or chilled
0344	Fish fillets, frozen
0360	Crustaceans and molluscs, fresh, chilled, frozen etc.
0540	Vegetables, fresh, chilled, frozen/preserved; roots, tubers
0541	Potatoes, fresh or chilled, excluding sweet potatoes
0542	Beans, peas, lentils & other leguminous vegetables
0544	Tomatoes, fresh or chilled
0545	Other fresh or chilled vegetables
0546	Vegetables, frozen or in temporary preservative
0548	Vegetable products, roots & tubers, for human food
0570	Fruit & nuts (not including oil nuts), fresh or dried
0571	Oranges, mandarins, clementines and other citrus
0572	Other citrus fruit, fresh or dried
0573	Bananas, fresh or dried
0574	Apples, fresh
0575	Grapes, fresh or dried
0576	Figs, fresh or dried
0577	Edible nuts (excluding nuts used for the extracting of oil)
0579	Fruit, fresh or dried, n.e.s.

C.1 Estimating a different specification

In chapter 6, we estimated the effects of containerisation through a country-pair time variant variable ($Cont_{ijt}$). However, if we use the classification of the products according to their containerisability of 1968, we can develop a potential new measure which is specific to containerisable products. If we interact the country-pair specific variable with a containerisability indicator, we get a variable that is specific to containerisable products ($Cont_{ijkt}$). We introduce this new variable in equation 6.2. The 'treatment' equation becomes:

$$\Delta lnx_{ijk,t} = \gamma_1 + \gamma_2 \Delta Container_{ij,t} + \gamma_3 \Delta Cont_{ijkt} + \gamma_4 \Delta Policy_{ij,t} + \gamma_5 \overrightarrow{D_{ijk}} + u_{ijk,t} \quad \text{(C.1)}$$

The treatment group of the newly introduced variable is all containerisable products that are moved in containers and the control group is all non-containerisable products. This new product specific variable would then pick up the difference in the effects of containerisation on containerisable trade versus non-containerisable trade.

Given that the product containerisability classification that we use dates back to 1968, we are not sure whether those products that are defined as non-containerisable could have become containerisable or their trade were affect by containerisation. This means that by using those products as the control group is not accurate. The results from estimating the above equation are hence only suggestive and no causal statements can be made based on them.

In this specification, we have two container treatment variables, $Container_{ijt}$ and $Cont_{ijkt}$. The first variable is the same one as in equation 5.2. The second one is country-pair and product specific.

Table C.2: Effect of Containerisation, 4-digit Product level regressions, 5-year Intervals and 7 periods; First Difference Model

	Dep.Var: ln trade(ijk)	4-digit industry level			
		Entire Sample	North-South trade	North-North trade	South-South Trade
Port and Railway	Full Cont	0.674***	1.007***	0.388***	0.793***
		(0.0076)	(0.0113)	(0.0174)	(0.0220)
	full cont(ijk)	-0.011	-0.013	-0.027	-0.077***
		(0.0068)	(0.0090)	(0.0196)	(0.0210)
	FTA	0.339***	0.089*	0.407***	0.134*
		(0.0082)	(0.0348)	(0.0088)	(0.0595)
	Both GATT	0.349***	0.518***	0.035	0.243***
		(0.0088)	(0.0138)	(0.0277)	(0.0184)
	Common Curr	0.134***	0.179***	0.108**	-0.070
		(0.0149)	(0.0187)	(0.0381)	(0.0507)
	No. Countries	157	157	22	135
	No. Observations	2237820	1306788	633583	284406
	overall R^2	0.097	0.1121	0.103	0.133
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt
Port Containerisation	Port Cont	0.567***	0.842***	0.329***	0.789***
		(0.0074)	(0.0110)	(0.0150)	(0.0227)
	port cont(ijk)	-0.022**	-0.028**	-0.014	-0.090***
		(0.0069)	(0.0095)	(0.0148)	(0.0217)
	FTA	0.328***	0.068*	0.401***	0.131*
		(0.0082)	(0.0349)	(0.0088)	(0.0595)
	Both GATT	0.387***	0.606***	0.078**	0.243***
		(0.0088)	(0.0137)	(0.0277)	(0.0184)
	Common Curr	0.134***	0.176***	0.110**	-0.080
		(0.0149)	(0.0187)	(0.0381)	(0.0508)
	No. Countries	157	157	22	135
	No. Observations	2237820	1306788	633583	284406
	overall R^2	0.096	0.111	0.103	0.133
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt

Coefficients marked with *,**,*** denote significance at the 10%, 5% and 1% levels respectively.

Table C.3: Effect of Containerisation, 1-digit Product level regressions, 5-year Intervals and 7 periods; First Difference Model

	Dep.Var: ln trade(ijk)	1-digit industry level			
		Entire Sample	North-South trade	North-North trade	South-South Trade
Port and Railway	Full Cont	0.701***	1.282***	0.351***	0.858***
		(0.0232)	(0.0419)	(0.0828)	(0.0477)
	full cont(ijk)	-0.0133	0.0181	-0.0634	-0.0713
		(0.0213)	(0.0268)	(0.0832)	(0.0471)
	FTA	0.286***	0.158	0.318***	0.347**
		(0.0365)	(0.111)	(0.0365)	(0.133)
	Both GATT	0.278***	0.271***	0.148	0.289***
		(0.0242)	(0.0468)	(0.106)	(0.0402)
	Common Curr	0.0999	0.192***	0.360*	-0.000
		(0.0513)	(0.0676)	(0.157)	(0.104)
	No. Countries	157	157	22	135
	No. Observations	237106	146062	24342	66702
	overall R^2	0.108	0.129	0.114	0.129
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt
Port Containerisation	Port Cont	0.664***	0.806***	0.428***	0.949***
		(0.0233)	(0.0359)	(0.0681)	(0.0494)
	port cont(ijk)	-0.039	-0.011	-0.237***	-0.112*
		(0.0223)	(0.0283)	(0.0589)	(0.0485)
	FTA	0.264***	0.156	0.304***	0.350**
		(0.0365)	(0.111)	(0.0367)	(0.132)
	Both GATT	0.289***	0.344***	0.170	0.292***
		(0.0242)	(0.0468)	(0.106)	(0.0402)
	Common Curr	0.099	0.192**	0.364*	-0.004
		(0.0513)	(0.0677)	(0.157)	(0.104)
	No. Countries	157	157	22	135
	No. Observations	237106	146062	24342	66702
	overall R^2	0.107	0.126	0.114	0.1300
	FE	it,jt,kt	it,jt,kt	it,jt,kt	it,jt,kt

Coefficients marked with *,**,*** denote significance at the 10%, 5% and 1% levels respectively.