Exotic trade and trade in exotics:

The impact of containerization on new trade

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STILL VERY ROUGH AND PRELIMINARY, PLEASE DO NOT QUOTE (YET).

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Abstract

Economists and historians agree that technological change is a main driver of trade and economic activity. However, a key challenge for statistical inference is that the path of technological change is often gradual and also often caused by the degree of trade and economic activity. This paper exploits *exogenous* features of the 1960s/70s container revolution to estimate the impact of the introduction of refrigerated containers (or reefers) on the new trade of temperature sensitive products. Our identification strategy is justified by a historical narrative which suggests that the containerization of bilateral trading routes was exogenous to the growth of trade in 'reefer commodities' and stimulated trade in non-traditional (exotic) non-bulk commodities such as pharmaceuticals, photo film and sensitive instruments. Our study combines previously collected data on variations in the container usage on bilateral trade routes with newly collected data on temperature sensitivity and applies them to 5-digit product level trade flows. Our preliminary estimates suggest that the introduction of reefer containers caused an increase in the likelihood of new trade in temperature sensitive products. We also identify a role for containerization to have increased the likelihood of trade across the equator.

JEL classification: F13

Keywords: Trade in temperature-sensitive products; Extensive margin; Impact of refrigerated containers.

1. Introduction

It is well-known that the growth of trade can occur either along the *intensive margin* (more trade of the same products) or the *extensive margin* (trade of new products). Given the potentially large welfare effects from trade along the extensive margin, academic researchers have examined the impacts of trade liberalization experiences on changes along the extensive margin.[1] Neglected within the existing literature has been the role of technological change in stimulating the extensive margin.

This paper focuses on the impact of what has arguably been the defining global technological change in the transportation of goods in the last century: the container revolution. In previous work (Bernhofen et al (2013)), we exploited cross-sectional and time variation in countries' adoption of port or railway container facilities to estimate the effects of the container revolution on total bilateral trade. In this paper we exploit exogenous features of the 1960s/70s container revolution to estimate the impact of the introduction of refrigerated containers (or reefers) on the growth of trade along the extensive margin, defined as the occurrence of trade in new products to new destinations.

Our identification strategy is justified by our historical narrative, described in section 2, which suggests that the containerization of bilateral trading routes was exogenous to trade in 'reefer commodities' and stimulated trade in temperature sensitive products (henceforth TSP). We argue that the expected future growth of the extensive margin of trade in TSP was not a motivation to containerize. TSPs comprise of chilled and frozen food items but also manufactured products such as pharmaceuticals, chemicals, and camera film and processed food such as chocolate and other confectionary. Transportation of such goods is distinct from general cargo, requiring refrigeration to maintain temperatures and guarantee the integrity of the products involved, in particular over longer journeys (Arduino and Parola, 2010).

Our study combines previously collected data on variations in the container usage in bilateral trade routes with newly collected product level data on variations in temperature sensitivity. To determine which products are temperature-sensitive we rely on information from an engineering study by Rytter (2009) into the transport of temperature sensitive goods in Europe. Within that study 4-5 digit ISIC codes are classified on a scale of 1 to 4 according to their temperature sensitivity. This index takes into account the various temperature demands that a product requires during transportation, such as the temperature and temperature range a product will tolerate, but also factors such as their potential for contamination by and of other materials. Data on the containerization of bilateral trade routes and the degree of containerizability at the product level is taken from

[1] Hummels and Klenow (2005) provided one of the first studies. Arkolakis et al. (2008), Mukerji (2009) and Debaere and Mostashari (2010) examined the role of trade liberalization in Costa Rica, India and the US, respectively. Felbermayr and Kohler (2010) examined entrance into the GATT/WTO, Flam and Nordstroem (2006) examined the impact of a single currency in Europe and Kehoe and Ruhl (2013) have examined the role of structural change.

Bernhofen et al. (2013).[2] These data are then applied to explain variations in SITC 5-digit bilateral trade flows taken from the UN Commodity Trade (Comtrade) database. Our preliminary estimates suggest that the introduction of reefer containers increased the likelihood of new trade in temperature sensitive products. We also identify a role for containerization to increase the likelihood of trade across the equator.

The next section of the paper provides background information on reefer trade, trade in temperature sensitive products and reefer containers. Section 3 describes the data sources and provides some descriptive statistics on the extensive margin of trade. Section 4 contains some preliminary estimates and some robustness checks. Our drafts ends at this point because it is still 'too early' to conclude.

2. Transportation of temperature sensitive products

Before the advent of refrigerated containers the shipping of TSPs was done in specialized vessels (known as reefer ships), and by specialist shippers - this was largely done by tramp rather than the liner shipping lines used for most general cargo.[3] It also required ports to invest in storage of refrigerated cargo and therefore often used specialized ports. The traditional reefer commodities were of frozen meat (carcasses), dairy produce (mainly butter), citrus fruits, deciduous fruits[4] and bananas. These trades were characterized by their large volumes and in the case of bananas their year-round harvest periods.

Of primary interest in this paper is the use of reefer containers for the transportation of small volumes of new and difficult to transport commodities outside of the traditional reefer fleet.[5] According to Drewry (1990) the shipping of new types of TSPs in reefer containers was an important part of the growth of total trade in TSPs over the 1970s and 1980s and distinct from trade in traditional reefer commodities. For this group of products, the advent of containerization meant that their international trade became cost-effective for the first time, but only as part of larger containerized cargoes of non-TSPs. For example, electric points for integral reefer containers were available on almost all liner containerships by the late 1970s.[6] These slots were available only in small quantities and were not necessarily, and according to Drewry (1983) not very often, used for perishable

[2] Bernhofen et al. (2013) construct the bilateral container adoption variable from various editions of the *Containerization International Yearbook.* Information on the degree of containerisability of a product group is based on a 1968 study the *German Engineers Society*.

[3] There were also part-referigerated ships carrying part-refrigerated cargoes in 'season'.

[4] Apples, pears, and grapes.

[5] The first purpose-built reefer container vessels were introduced to the Europe-Australia trade in 1969, and incorporated central refrigeration machinery to provide cold air to over 300 (porthole) containers. According to evidence from the Containerisation International Yearbook for 1974 the first fully-cellular refrigerated vessel entered service in 1973 (the Remuera operated by Australian National Line between Europe and Australia/New Zealand).

[6] Reefer containers are known as either porthole or integrated reefers depending on the method of their refrigeration. The temperature in porthole containers is controlled via a refrigeration unit on board the ship, while for integral reefers they are part of the container itself. Porthole containers have the advantage over integral reefer containers that they do not require their own power supply on board ship, but the disadvantage that they require specialised refrigeration equipment at the dock-side.

goods as they could also be used for containerized general cargo. As the shipping consultants Drewry write "where they are used, it is often for minor reefer cargoes" (Drewry, 1983, p13) of the type we are interested in here.[7] The infrequency with which reefer slots were used demonstrates that the small volume in which much of this trade in TSPs occurred and indicates that trade in these products would not by themselves have justified the size of the capital investments needed to adopt the container.

That the realized volumes of trade in TSPs were small does not by itself preclude the possibility that the growth in TSP trade was expected to have been large and it was this that justified the investment in the container technology. The anticipation of future growth of trade in TSPs would however have justified an expansion of the specialized reefer shipping fleet and not containerization.[8] For larger volume trade specialist reefer ships were favored.[9] Container ships with reefer capabilities had lower fixed costs, but higher variable costs compared to reefer-ships or even fully-refrigerated container ships (Drewry, 1983).[10] As a consequence, average costs were lower compared to shipping using specialist reefer ships when trade volumes were small, or for collections of products that required different ambient temperatures and temperature ranges, but were higher for large volume, frequent, bilateral trade (See Figure 1).[11] It is also worth noting that owners of the reefer shipping fleet do not appear to have recognized the potential that containerization might have on expanding the range of products that they could carry and the adoption of the container was much more uneven and much slower than for general cargo as a consequence. [12] Reefer shippers recognized the potential loss of market share to carriers of general cargo with reefer containers but sought to protect their markets in traditional reefer commodities by improving efficiency through other means.

[7] They also relied on a technology that had been developed for the use in the specialist reefer industry, but which could be adopted by vessels and ports relatively easily.Integral reefers had been around since the mid-1950s, when road trailers were converted with insulation and basic refrigeration units on US coastal routes. However, these were generally rudimentary and temperatures could not be accurately controlled. According to Drewry these were largely sidelined in the initial stages of the containerization by the refer industry by the introduction of porthole reefer containers. Porthole containers were more similar to the technology that was used to refrigerate entire ships. Innovations in the cooling systems used in integral reefers took place during the 1970s and 1980s (Containerisation International, 1989).

[8] It was for this reason that there was surprisingly little impact on the traditional reefer trades from the containerization of the deep-sea general cargo. As the shipping consultants Drewry write "Even viewed on an historical basis, the wholesale containerization of deep sea trades has actually had little impact upon the market share of the major tramp operators" (Drewry, 1990: p14-15).

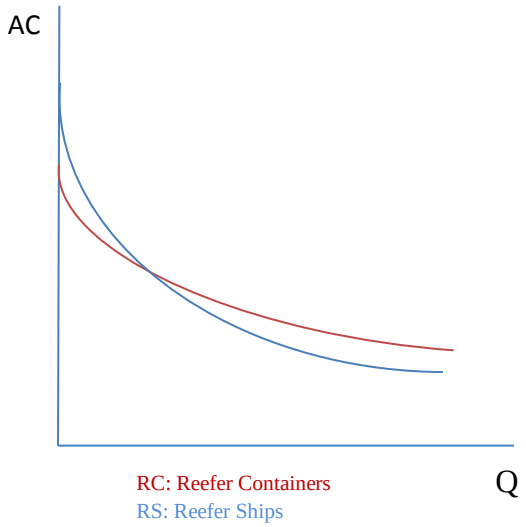
[9] Shippers sought ways to avoid the expense of refrigerating cargo. Over shorter-distances ro/ro (roll-on, roll-off) ships with fans to ventilate rather than refrigerate cargo were used. There were also developments over this time period in coating products or irradiating it.

[10] The containerization of the banana trade used for example integral-reefer container ships.

[11] Consistent with this Drewry (1983) report that the smallest class of full reefer-ships (60,000-199,000 cu.ft) were inactive for twice as long as the next category of size (200,000-299,000 cu.ft).

[12] due to issues about spoiling, there was also a debate over whether temperature sensitive cargoes such as bananas could be carried in containers. It was also recognized that insulating each box rather than the whole ship was an inefficient use of available space.

Figure 1



2.1 An illustrative commodity: trade in Kiwis

Within the reefer industry, trade in kiwifruits is often held up as an example of not only the new trades that were made possible by containerization, but also the cost-advantages of the transportation of TSPs using specialized reefer-vessels as volumes grew. Known as the Chinese gooseberry up until their name change in the early 1960s, the kiwifruit is very temperature sensitive, requiring close temperature management to lengthen its shelf-life; temperature has to be kept between -0.5 and 0.5 degrees. Kiwifruits were first harvested for the domestic market in New Zealand from the early 1940s and they were exported in small volumes to countries such as the UK and Australia in 1952-53 and to the US in 1962. In the early 1970s export volumes amounted to only a few hundred trays (each containing between 33-42 fruits).[13] It also has a short harvest period, primarily in May-July, and therefore was not suited to dedicated liner shipping, either by reefer vessels or by whole reefer-container ships. Export volumes grew quickly following successful marketing campaigns by the Kiwifruit Export Promotion Committee, which was formed in 1970 and the Kiwifruit Authority, which was formed in 1977 (Skallerud and Olsen, 2011). By 1987 exports were 45 million trays (Drewry, 1990). These initial shipments were carried by the container lines of Europe, exploiting the availability of container vessels for trade in general cargo (Drewry, 1990). By the 1984 volumes of kiwifruit exports from New Zealand had grown sufficiently such that

[13] A standard 20ft container can accommodate 2,088 trays (12 pallets each with 174 trays) (Drewry, 1988).

the economies of scale now favored conventional reefer ships and within a few years the majority of trade was carried in this way.[14] This was partly for reasons of cost but also to ensure sufficient capacity.

As the kiwifruit example shows, the decision to adopt the container on the route between New Zealand and Europe occurred as a result of the economies of scale and efficiencies offered by the containerization of general cargo on the trade route between Australia, New Zealand and Europe. The new trade in kiwifruit was therefore contingent on the frequency and size of vessels on a liner-container route. The containerization of a bilateral trade route, was from the perspective of trade in TSPs, an exogenous event. We exploit this to identify the effect of containerization on the extensive margin of trade in TSPs using non-containerized trade routes as a counterfactual.

2.2 Reefer Containers

It is also important to note that during the period up to the mid-1960s innovation of reefer containers was undertaken by equipment manufacturers in order to serve the specialized reefer market (Drewry, 1990). For the shipping lines the relatively short-distances, combined with limited market size limited the incentive to innovate (Drewry, 1990). However, as reefer containers gained popularity and due to the technical sophistication of the temperature control units, there was a shift towards chilled commodities and more products were shipped in reefer containers on deep-sea routes[15].

Reefer containers come in two forms: integral and porthole. Porthole containers are containers that are connected to a central refrigeration unit in the ship. This type of containers is more appropriate for large volume, homogeneous cargoes. Porthole containers require shore side infrastructure to insure continuous temperature control. Integral containers have their own machinery and only require an external supply of electricity to operate at sea or on land. Typically, integral containers are more expensive than porthole containers but they are more suitable for small and high value shipments as well as highly temperature-sensitive products (such as pharmaceuticals).

The containerization of deep sea reefer trades from 1969 onwards was a pronounced shock to the conventional reefer market. The threat of containerization led the owners of conventional reefer vessels to lower their costs in order to withstand the inevitable assault by the container lines upon their traditional

[14] According to Drewry (1988) there were 9 shipments of kiwifruits from New Zealand using reefer-ships in 1985, 23 in 1986 and 42 in 1987.
[15] *Dewry Shipping Consultants Ltd (1990)*

markets. Thus the move towards large-scale palletization of reefer cargoes began as a defensive measure against containers rather than as a natural development from break-bulk, labor-intensive handling methods[16].

The first major advance in reefer container shipping occurred towards the end of the 1960s when the extension of containerization into new deep sea trades radically altered the demands placed on the equipment used, and led to the adoption of totally new concept- the porthole reefer box. The very first liner service to incorporate refrigerated cargoes into its regular liftings (on the Europe-Australia trade) seized the opportunity presented by the northbound meat cargoes on this route to develop the concept of the fully cellular containership with complete holds dedicated to reefer boxes. Containerization helped the trade of chilled meat (versus frozen meat) due to better control of temperatures (around -1.5 degrees)[17].

The major costs in conventional handling of reefer commodities are the same as those for conventional ships. Ships are tied up in ports while large numbers of dockers unload or load them, while multiple handling, particularly in the destination country, is expensive and can be damaging. Support for this claim is provided by the reaction of the reefer shipping industry to containerization, who despite their experience in shipping perishable goods do not appear to have anticipated that containerizing their fleet might open new markets to them. Instead their reaction appears to have been an attempt to protect current market share,[18] and in some quarters displays evidence of resistance to the introduction of containerization. By the end of the 1980s, two decades or so after the start of the international containerization era, the general characterization of the reefer industry prior to containerization had not changed. The bulk of the shipping was still of traditional reefer commodities and was still conducted by a specialized shipping fleet. Containerization had made some impact, although this was limited because the response by some reefer carriers was to improve efficiency through the adoption of alternative technologies,[19] and because not all products were suited to be carried in containers.[20] According to Drewry (1990) the impact of containerization of trade in traditional reefer commodities could be summarized as belonging to either the wholesale containerization of large volume commodity trades e.g. meat and dairy trade between Australia/New Zealand and Europe/US, or the partial containerization of large volume commodity trades such as South African fruit to Europe and trade in bananas on some routes.

[16] *Dewry Shipping Consultants Ltd (1990)*
[17] *Dewry Shipping Consultants Ltd (1990)*
[18] As Drewry (1990) writes "It is worth stressing again that most major reefer containership operators containerised their own conventional trades, rather than appropriating the business of competitors." (p16).
[19] For example, through the greater use of pallets. Pallets had been primarily used on the dock-side to help with the transportation of products. The extension of their use onto ships, which itself required investments in new ships able to accommodate palletized trade, reduced the amount of labor required needed to load and unload ships. On shorter trade routes, especially those involving routes that were largely across land, there was also greater use of ro-ro (roll-on roll-off) shipping, often using ventilated rather than refrigerated lorries.
[20] Rates of spoiling for some fruits were faster when placed in containers.

3. Data Sources and Descriptive Statistics

3.1 Data Sources

We use commodity trade flow data that comes from the UN Commodity Trade (UN Comtrade) database. The advantage of this dataset is that it records commodity trade for all countries from 1962 at the SITC 5-digit product level. We restrict our sample to trade where at least one of the parties is an OECD country. This is because OECD countries dominated world trade in our period of concern and OECD countries were the pioneers in adopting the container technology[21]. The dataset reports trade flows of around 200 countries (including 23 OECD countries) of which we have containerization information on 157. There are 1371 products under the 5-digit SITC (Rev. 1) product classification[22].

To investigate products that are sensitive to temperature variation we rely on information from an engineering study by Rytter (2009)[23] in which products (ISIC) are classified on a scale of 1 to 4 according to their temperature sensitivity. A value of 1 on the index is given to products which are not temperature sensitive and a 4 is given to goods which are most temperature sensitive. We concentrate on those products that are considered to be either sensitive or very-sensitive (3 and 4 on this scale). There is variation in this index both within and across categories of trade. In total there are 253 products that are classified as temperature sensitive or very sensitive, 812 products that are not temperature sensitive and 306 products that are somewhat sensitive. Of the 197 products within chemicals 160 are classed as only slightly sensitive and 24 are sensitive or very sensitive, whereas in manufactured goods 394 are classed as not sensitive and 9 are slightly sensitive.

Temperature sensitive products are unevenly distributed across the various SITC codes. Over half are within the food and live animals sector, a further 25% are amongst the miscellaneous manufacturing goods and 12% are in Chemicals. There are no temperature sensitive products in animal goods and manufactured goods.

Data on the containerization of bilateral trade routes and the degree of containerizability at the product level is taken from Bernhofen et al. (2013). Gravity control variables are taken from CEPII[24].

[21] OECD countries until 1988 are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States (23 countries).

[22] In effect, for some products, the 4-digit product code would be the most disaggregated level. For these products, the 4-digit product classification is used.

[23] *Transport of Temperature Sensitive Goods in Europe: Definition, Limitations, Flow Analysis and Case Studies*, (2009).

[24] www.cepii.fr

4. Empirical Specification and Estimation

We attempt to identify the effect of the container technology on the growth of new trade using a difference-in-difference style framework. The dependent variable is a 0/1 variable that measures the import status of each country-pair and product. It takes the value of one if country i imports a positive amount of product k from country j in a given year t and zero otherwise.

To identify the causal effect of containerization we restrict the sample to containerizable TSPs that were not traded in 1968. We use 1968 as the pre-containerization time period as this is the year before the first documented use of (porthole) reefer boxes on container ships. As made clear in the discussion of the reefer industry our identification strategy might be considered valid for a particular sub-set of potential trade flows. Given our interest in new, small volume trade flows that were facilitated by the advent of the container we exclude traditional reefer products such as meat, fish and bananas which were carried by specialist reefer shipping lines. We further restrict the set of products to include only those that can be carried by the container. This excludes trade in products such as live animals from the analysis. We also restrict ourselves to early adopters of the container, on the basis that electricity points for integrated reefer boxes were ubiquitous across the container ships by the 1980s and therefore future trade in TSPs could have been used as a motivate to adopt the container the greater is the length of time after 1969. We initially define treatment as the bilateral adoption of the container by 1973. We test the robustness to the use of the bilateral adoption of the container by 1978. The regression equation that we use for estimation takes the following form.

$$\left(y_{\{ijk,t+1\}}\middle|\left(y_{\{ijk,t\}}=0\right)\right)=\beta_1+\beta_2 cont_{\{ij\}}+X'_{\{ijt\}}\lambda+\alpha_{1_{it}}+\alpha_{2_{jt}}+\alpha_{3_k}+\epsilon_{\{ijk,t+1\}} \quad (1)$$

where $y_{\{ijk,t+1\}}$ is the import status of product k between the country i and country j at time t+1. Since the dependent variable is either zero or one, the estimated equation becomes a linear probability model in which the probability of product k being imported by country i is estimated. On the RHS of the equation containerization is captured by country-pair specific variable $cont_{\{ij\}}$,

We also include a number of gravity and policy variables and these are: distance, common language, border, colonial links, common currency, free trade agreements (FTAs), and GATT membership. We also control for trade preferences. These variables are summed up in the matrix X. We also include a full set of origin (j), destination (i) as well as product (k) dummies to control for unobserved country and product characteristics.

We compare the effects of treatment on the probability that product k is imported by country i from country j relative to a counterfactual which we capture using trade in containerizable TSPs amongst pairs of countries that had not adopted the container by 1973 (1978 when testing robustness). The counterfactual

therefore includes trade in TSPs from countries that never amended port or rail infrastructure to handle container shipsments.

4.2 **Initial Evidence**

We provide some initial evidence of the effects of containerization on trade flows in Table #. The Table shows that of the 639,957 country-product triads that were not traded in 1968, 37,638 of these were being traded in 1973. This represents 5.9% of the non-traded triads in 1968. By 1978 the number of new product-country trades had grown to 52,087 and to 57,394 by 1983 (8.1% and 9.0% of the total respectively). Of the new trades in 1973, 22,209 were by countries that had adopted the container by 1973, a figure that rises further to 29,887 in 1978 and 32,517 in 1983.

When expressed as a percentage of the total number of country-products that could be traded the effects of containerization become somewhat more impressive. Of the 639,957 country-product triads that were not traded in 1968, 140,239 belonged to country-pairs that became containerized by 1973 and 499,718 to country-pairs that did not. By 1973 just 3.1% of the possible triads were being traded by country pairs that did not containerize, versus 15.8% of possible triads that did. By 1978 this figure was 21.3% for containerized countries and 4.4% for non-containerized country pairs and this rises further still by 1983. The growth of the extensive margin of trade would therefore appear to have been more rapid amongst countries that both adopted the container. This growth of trade is shown in Figure 2, where we also include the trading status of products in 1978 and 1983. These new trades are primarily in four categories, food products, crude materials, chemicals and miscellaneous, with the largest number in the latter two categories. Pharmaceutical products are included under chemicals, while the miscellaneous category includes photographic equipment including camera film. For all categories the number of new trades in 1973 is higher for containerized versus non-containerized bilateral pairs except for crude materials. Temperature sensitive crude materials relates to various types of animal skin and furs such as wool.

Similar patterns are observed when we define treatment as those countries that containerize between 1966 and 1978 and study the growth of the extensive margin between 1968 and 1978 (1983). Now we find that of the 639,957 non-traded product-country combinations in 1968 8.1% (9.0%) become traded by 1978 (1983). These new trades are disproportionately made up of countries that containerized between 1966 and 1978. Of the 639,957 zero observations in the trade data in 1968, 304,696 (47.6%) were by countries that containerized in the future. Out of these observations for future containerizers 13.6% (15.0%) become traded by 1978 (1983), compared to 3.2% (3.5%) for countries that did not containerize by 1978 (1983).

Figure 2: Growth rates in the extensive margin

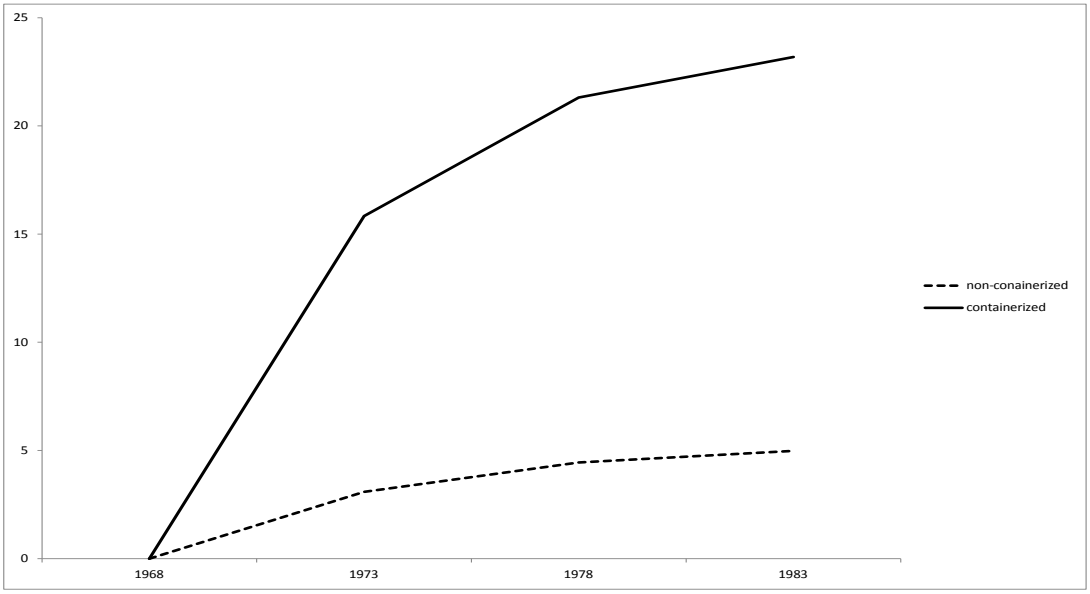


Table 1: New Trades

	Containerized Countries	Non-Containerized Countries	Total
Containerize 1966-1973			
1973 Newly traded (%)	22,209 (15.8%)	15,429 (3.1%)	37,638 (5.9%)
1978	29,887 (21.3%)	22,200 (4.4%)	52,087 (8.1%)
1983	32,517 (23.2%)	24,877 (5.0%)	57,394 (9.0%)
Containerize 1966-1978			
1978 Newly traded (%)	41,490 (13.6%)	10,597 (3.2%)	52,087 (8.1%)
1983	45,724 (15.0%)	11,670 (3.5%)	57,394 (9.0%)

Parallel Trends

Difference-in-difference (DID) estimates are invariably scrutinized based on the extent to which the control group represents the valid counterfactual. Key to this approach is the identifying assumption of parallel trends. Given that we study only a single pre- and post-treatment outcome and all of the products that we study were not traded in 1968, formal analysis by, for example, comparing pre-treatment trends across a number of time periods is not possible. Instead, to understand the growth of the extensive margin, we compare the new trades that occurred between 1964 and 1968 using the fact that this time period was prior to the advent of the reefer container in integrated or porthole form.

Before reporting on more formal evidence using a placebo regression of future treatment we report the number of import-triads that were not traded in 1964 and whether they were imported or not by 1968,

separating observations according to whether they containerize at some point in the future (any point between 1966 and 1983). The table shows that of the 530,106 not traded country-product combinations in 1964, 26,510 become traded in 1968. Of these 5,389 were by country-pairs that did not both adopt the container in the future and 21,121 by country-pairs that did. This represents a very similar proportion of the country-product pairs in each group; 4.2% for non- containerizers as compared to 5.3% for future containerizers. In the previous section we reported that the rate of growth of the extensive margin for untreated observations in the period after 1968 was between 3% and 5%.

In Table 2 we test this more formally by running a placebo test using future containerization as a potential explanation for the import status of products in 1968 that were not being imported in 1964. Conditional on origin, destination country and product effects to control for other determinants of the growth of the extensive margin of trade including GDP of the origin and destination countries we find some evidence that future containerizers were, if anything, less likely to import in 1968. We note however that the estimated difference in this effect is 0.9% indicating that any differences are very small.

Whilst we might think of the use of all future containerizes as the most demanding comparison of the parallel trends assumption that we might make, in the regressions reported below we restrict the sample to include bilateral-observations that containerize between 1966 and 1973 and 1966 and 1978 to match the treatment periods we report in the main regression results. In regression 2 in Table 2 we report a regression using the same specification as in regression 1 but defining future treatment as bilateral pairs that containerize between 1966 and 1973 (we exclude observations where containerization occurs between 1973 and 1978). In regression 3 we consider observations that containerize between 1966 and 1978 (excluding future observations where containerization occurs between 1978 and 1983). In both of these regressions we find no significant difference between future containerizers and non-containerizers over the period from 1964 to 1968. In regression 2 the point estimate is now positive, but is small (0.4%) and not statistically significant at conventional levels. In regression 3 the results are even more emphatic, the point estimate is 0.03%. We conclude from this exercise that the assumption of parallel trends would appear reasonable for treatment that we study.

Table 2: Parallel Trends

Regression no.	**1**	**2**	**3**
Import Status	**1968**	**1968**	**1968**
Containerization date	**1966-1983**	**1966-1973**	**1966-1978**
$Cont_{ij}$	-0.0089***	0.0039	-0.0003
	(0.003)	(0.003)	(0.002)
N	530,106	213,238	530,106
Standard errors	Robust	robust	robust

Controls	Importer, exporter, product	Importer, exporter, product	Importer, exporter, product

Econometric Results

In table 3, we present the results of estimating equation (1). This regression shows that compared to non-containerized country pairs, previously non-traded containerizable TSPs (in 1968) were more likely to be traded in 1973 if both countries had adopted the container by 1973. The effect is also economically significant, the results suggest that this probability is increased by a little under 9%. As argued in Section 2, because trade in TSPs would not have justified investment in the container the timing of adoption can be viewed as exogenous and therefore this can be viewed as the causal effect of this particular technological change on the country-product extensive margin of trade.

We would anticipate that the effect of the container should increase as it became more deeply embedded in the transport infrastructure of countries. In regression 2 we study whether temperature-sensitive products that were not traded in 1968 were more likely to be traded in 1978 by countries that had both adopted the container by 1973, while in regression 3 we consider whether those products were being imported in 1983. In each of these regressions we exclude observations for countries that containerized after 1973 (in regression 2 this relates to country-pairs that containerized between 1973 and 1978 and in regression 3 the 10-years between 1973 and 1983). The effect of this is to constrain the set of observations within the counterfactual to include only late adopters of the container (regression 2) and non-containerized pairs of countries (regression 2 and 3). We find that the effects of containerization are even larger in these regressions. The estimated effect of containerization is 12% in regression 2 and 45% in regression 3.

Treatment within Table 3 occurs when both countries adopt the container and is studied at varying lengths of time after 1968, the year before reefer containers were introduced. This setting ignores that some bilateral pairs were treated for a longer amount of time than others. This restriction would appear unwarranted given the evidence from regressions 2 and 3 that the effects of containerization increase with time. In regression 4 we capture this by introducing a variable that counts the number of years since the bilateral adoption of the container alongside the 0/1 bilateral container variable. The results from this regression indicate that the adoption of the container increases the extensive margin of trade by some 7% but that this effect increases with time. The increase in the probability of importing TSPs in 1973 is estimated to be 7.6(=7+0.6)% for observations where the container was adopted in 1972, compared to 11.2 (=7+ 4.2)% for those countries that had both adopted the container for 7 years.

Thus far we have taken a rather conservative approach and limited the timing of treatment to occur before 1973. In regression 5 we extend the time period to include countries that had containerized by 1978, while in regression 6 we also control for the number of years since containerization in the bilateral-pair began. We find that the results are robust to the use of data on the containerization of countries to include the period up to 1978. We again find that temperature sensitive products were more likely to be imported by countries that had adopted the container, where the estimated magnitude of this effect is very similar to regression 1, and that this increases with the length of time that the bilateral pair has been containerized.

Table 3: Benchmark Results

Regression no.	**1**	**2**	**3**	**4**	**5**	**6**
Import Status	**1973**	**1978**	**1983**	**1973**	**1978**	**1978**
Containerization date	**1966-1973**	**1966-1973**	**1966-1973**	**1966-1973**	**1966-1978**	**1966-1978**
$cont_{ij}$	0.088***	0.127***	0.452***	0.071***	0.090***	0.078***
	(0.003)	(0.004)	(0.012)	(0.004)	(0.002)	(0.003)
No. years since cont. began				0.006***		0.003***
				(0.001)		(0.000)
N	609,729	453,031	267,269	609,729	609,729	609,729
Standard errors	robust	robust	robust	robust	robust	robust
Controls	Importer, exporter, product	Importer, exporter, product	Importer, exporter, product	Importer, exporter, product	Importer, exporter, product	Importer, exporter, product

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Sample restricted to temperature sensitive and containerizable products.
All regressions control for FTA, GATT membership, border, common language, distance, colonial links, trade preferences as well as importer, exporter, and product dummies.
Bilateral network depth controls for total bilateral containerisable trade in the previous period (t-5).

Robustness Checks

In this section of the paper we establish the robustness of the main results in Table 4, where this includes the estimation method, the effect of possible omitted variables, the measure of temperature sensitivity and the measure of containerizability.

In regression 7 and 8 in Table 4 we consider the possibility of omitted variable bias, in this case that there are omitted bilateral-product specific factors that explain the increase in bilateral trade between containerized countries. To control for this possibility we pool the data between 1968 and 1978 and estimate a fixed effects model. This is reported in regression 7. In regression 8 we additionally add time effects to explore whether there were common period specific shocks that might explain our results. We find that there is a modest impact

on the magnitude of the estimated effect of containerization in these regressions and the main results carry over.

In regressions 9 and 10 we compare the effects of containerization on products classified by (reference) as either sensitive (group 3) and very-sensitive (group 4). The point estimates for the two groups are identical, suggesting that the results we have derived so far are not-sensitive to this choice.

Finally in this section we change the definition of the containerizability of products. According to (reference) products can be classified as being 'suitable for containers' (Class A), 'slightly suitable for containers' (Class B) , or 'non-suitable for containers' (Class C).). Thus far we have defined containerizable products to be products from either Class A or Class B. In regression 11, we redefine containerizable products to be Class A products only. Again this has no bearing on the conclusions that we have drawn about the effects of containerization.

Table 4: Robustness

Regression no.	**7**	**8**	**9**	**10**	**11**
Import Status	**1968-1978**	**1968-1978**	**1973**	**1973**	**1973**
Containerization date	**1966-1978**	**1966-1978**	**1966-1973**	**1966-1973**	**1966-1973**
	panel	panel	Sensitive TSP	Very-sensitive TSP	Containerize
$Cont_{ij}$	0.068*** (0.001) drops	0.042*** (0.001) drops	0.087*** (0.007)	0.087*** (0.003)	0.089*** (0.004)
N	1,829,187	1,829,187	214,498	389,255	491,217
Standard errors	robust	robust	robust	robust	robust
Controls	Importer – exporter – product	Importer – exporter – product, year	Importer, exporter, product	Importer, exporter, product	Importer, exporter, product

Extensions

Spillovers from non-reefer trade

The history of the reefer trade over our time period makes clear that reefer boxes were first made available on container ships that primarily served general cargo. The effect of containerization on trade in temperature sensitive products is therefore likely to differ according to the availability of general cargo trade. We label this as non-reefer trade and proxy for this using total trade flows in containerizable products between countries i and j at time t-1. We also include an interaction term of the container and network depth variables.

Even when trade flows are aggregated to the level of bilateral trade it is well known that they contain many zeros (references). This is also true in our data. In 1973 31% of observations have zero trade flows recorded between that country pair. By 1978 this figure has dropped to 21%. We would anticipate a difference in the effect on the probability of trade in TSP between country-pairs with no versus positive trade in non-TSP containerizable products. We therefore construct a zero-one dummy, equal to 1 when the trade flow in containerizable non-TSP products is positive and zero otherwise. We again include this in the regression along with an interaction with the containerization variable. In Table 5 in regression 12 we report the results for 1973 and in regression 13 the results for those countries that containerize between 1966 and 1978.

We find a consistent patter across these two regressions. The reference category in these regressions are non-containerized country-pairs where there is no trade in non-reefer products. For country-pairs where containerization of non-reefer trade occurred between 1966 and 1973 then we find that the probability that new trades occurred was 2.9% higher (given by the coefficient on the $cont_{ij}$ variable) than this reference group even when there was no bilateral trade in non-reefer products. For TSP products where there was positive bilateral trade in non-reefer products the results are more complicated, they are negative for small trade flows and positive for larger flows. Of particular interest in these results is the finding that the probability of trade by both containerized and non-containerized countries is affected by non-reefer trade, but the effect is over 5½ times larger for containerized country-pairs. This would seem to indicate a strong spillover effect from non-reefer containerized trade.

To provide a quantitative assessment of the non-linearity consider a hypothetical country-pair with a bilateral trade flow of just \$1. For this pair of countries the probability of new trade in TSPs occurring by 1973 is 16.7% lower than the reference group (given by the sum of the coefficient on the $cont_{ij}$ + non-reefer $dummy_{ijt}$ + non-reefer dum_{ijt}*$cont_{ijk}$ variables). This effect remains negative until logged trade flows reach 9.82 (\$18,463). Beyond this level of trade containerized non-reefer trade serves to act positively on the probability of trade flows. Over 86% of bilateral trade flows are above this value in the data (60% when the zero-flows are also included) The median value of the log of positive non-reefer trade flows in 1973 was 13.6 (\$806,130). At this value of trade the probability of trade in TSPs is an estimated 6.4% higher than the reference category. A standard deviation increase (an increase of 2.85 log points) from the means would raise this probability to 11.2%. From the results for 1978 the turning point in the data occurs at 9.2 (logged trade), while at the mean value of non-TSP trade the probability of new trade in TSPs is 7.3% higher than the reference category.

As already mentioned there is also an effect from non-reefer trade for TSP products in countries that did not-containerize. Given the absence of reefer containers on traditional (non-container) general cargo ships this is likely to capture the effect of short-distance trade in TSP where the need for reefer containers is less pressing.

When bilateral trade in non-TSP products is positive we find that the probability of new trade in TSPs in TSPs was positive only for bilateral trade volumes in non-TSP products above $17,365,569 (16.67 log points). Close to 7% of observations for this group are above this cut-off value. At the mean value of trade (logged bilateral trade = 13.1) the probability is 1.1% lower than the reference group.

Table 5: Spillovers from non-TSP trade

Regression no.	**12**	**13**
Import Status	**1973**	**1978**
Containerization date	**1966-1973**	**1966-1978**
$Cont_{ij}$	0.029***	0.037***
	(0.004)	(0.002)
Non-reefer $dummy_{ijt}$	-0.050***	-0.025***
	(0.002)	(0.002)
$cont_{ij}$ *Non-reefer $dummy_{ijt}$	-0.146***	-0.141***
	(0.006)	(0.004)
Log(non-reefer trade)$_{ijt-1}$	0.003***	0.001***
	(0.000)	(0.000)
$Cont_{ijktt}$* Log(non-reefer trade)$_{ijt-1}$	0.014***	0.013***
	(0.000)	(0.000)
N	609,729	609,729
Standard errors	robust	robust
Controls	Importer, exporter, product	Importer, exporter, product

Alternative Counterfactual

Our main finding that technological change can explain changes to the extensive margin of trade could be contested on the grounds that we are capturing other wider changes at the bilateral level that occur for containerized countries, say because of changes in to demand or non-container related policy factors that make it easier for trade. While we control for a number of country and policy factors within the regression we cannot completely rule out this possibility. Given the assumed bilateral nature of these omitted variables we approach this question by instead creating a new counterfactual that would rule out this possibility. To construct this counterfactual we use information on the non-containerisability of some temperature sensitive products. That is we restrict the sample to bilateral-pairs that containerize between 1966 and 1973 and then test whether the containerizability of products mattered or not for whether they become traded in 1968. The effects of the container are now identified, not from differences relative to non-containerized pairs of countries but, from differences in the suitability of some products to be transported inside of a container.[25]

[25] Given the time invariant nature of this product characteristic we exclude the product-effects from the regression.

We again begin by providing information for the parallel trends assumption. We find that of the 400,387 containerizable TSPs that were not traded in 1963, 5.3% start to be imported by countries which containerize in the future, whereas of the 14,331 non-containerizable products in these same countries 4.8% start to be imported by 1968. The rate of change in the extensive margin is again very similar to that observed for the control group when we study what happens to trade flows in the post-containerization period. We again also accept that containerizability of TSPs amongst future adopters of the container does not help to predict which products start to be traded between 1963 and 1968 in regression 14 in Table 6.[26]

Again this would lend support to the assumption that the parallel trends assumption holds within the data. Having established this we estimate the regression defining treatment according to whether containerization occurred in the period 1966-1973 (regression 15) or 1966-1978 (regression 16). We find that defining treatment according to the containerizability of yields strong evidence of an effect from containerization. Containerizable products were more likely to be imported compared to non-containerizable products within country-pairs that had adopted the container in regression 15, with an even stronger effect found in regression 16. The magnitudes of these effects are 1.7% in regression 15 and 4.1% higher in regression 16.

What might the effect be larger in the later time period? [1] We tested whether the abolition of most tariffs and non-tariff barriers to live animal imports by the EEC from the early 1970s to 1974/5 (United Nations, 1985) could explain increased trade amongst live-animal exports up to 1973. Defining the EEC to include the original 6 members (Belgium, France, Germany, Italy, Luxembourg, Netherlands) we find that whilst non-containerizable TSP trade by these countries was more likely, the effect of the container variable was both similar in magnitude to regression 15 and remained statistically significant (coefficient (t-statistic): 0.020 (4.01)). We choose not to report this regression.

The results from regressions 15-16 suggest that it might have been some initial adjustment in the behavior of the earliest containerizers. In regression 17 we compare the effects on products for country pairs that containerized at any point from 1966 to 1983. Here we again find a significant positive effect from containerization that is of a similar magnitude to when containerization occurs between 1966 and 1978. We replicate the analysis in regressions 18 and 19 but allowing for a longer period of adjustment. These regressions are similar in design to those presented as regressions 2 and 3 in Table 3. In regression 18 we find evidence that containerizable products for country-pairs that had adopted the container by 1973 were 5.9% more likely to be imported in 1978 compared to non-containerizable products. By 1983 we find this effect to be 6.9%.

Table 6: Alternative Counterfactual

[26] We find similar results if we restrict the analysis to include only countries that containerize between 1966 and 1973, or between 1966 and 1978.

Regression no.	**14**	**15**	**16**	**17**	**18**	**19**
Import Status	**1968**	**1973**	**1978**	**1983**	**1978**	**1983**
Containerization date	**1966-1983**	**1966-1973**	**1966-1978**	**1966-1983**	**1966-1973**	**1966-1973**
$Cont_k$	0.0010	0.017***	0.041***	0.038***	0.059***	0.069***
	(0.003)	(0.005)	(0.015)	(0.002)	(0.004)	(0.005)
N	283,967	138,733	300,977	493,337	144,279	150,877
Standard errors	robust	robust	robust	Robust	robust	robust
Controls	Importer, exporter	Importer, exporter	Importer, exporter	Importer, exporter	Importer, exporter	Importer, exporter

Crossing the Equator

Temperature sensitive products are affected by both the ambient temperature as well as the temper-range they can tolerate. A key component of the contribution of reefer technology has been to facilitate trade over distance in which the range of the outside temperature is subject to the greatest variation. The most obvious example of this occurs when products are shipped across the equator. If reefer containers have affected trade in the way described in this paper we might therefore anticipate that containerizable TSPs should benefit to a greater extent than non-containerizable products when the trade flows requires shipment across the equator. In Table 7 we repeat regressions 15 and 16 from Table 6 including the effect of crossing the equator (measured as a 0/1 variable) and the equator variable interacted with the containerization dummy (which captures the containerizability of products in these regressions).

In both regressions presented in the table we find that containerizable products where shipment transits the equator benefitted from the decision to adopt the container by pairs of countries through an increased probability of trade.

Table 7: The effects of the equator

Regression no.	**20**	**21**
Import Status	**1973**	**1978**
Containerization date	**1966-1983**	**1966-1973**
$Cont_k$	0.007	0.036***
	(0.044)	(0.003)
$Equator_{ij}$	-0.026**	0.017***
	(0.011)	(0.006)
$Equator_{ij}$*$Cont_k$	0.044***	0.016***
	(0.010)	(0.006)
N	138,733	300,977
Standard errors	robust	robust

Controls	Importer, exporter	Importer, exporter

5. Conclusion (still needs to be written)

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Appendix 1 Countries in the Sample

Algeria, Angola, Argentina, Australia, Austria, Bahamas, Bahrain, Bangladesh, Belgium-Luxembourg, Belize, Benin, Bermuda, Bolivia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Chinese Tapei (Taiwan), Colombia, Comoros, Congo, Costa Rica, Cuba, Cyprus, Democratic Republic of Congo, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Fiji, Finland, Former Burma, Former Czechoslovakia, Former USSR, Former Yugoslavia, France, French Guiana, Gabon, Gambia, Germany, Ghana, Greece, Guadeloupe, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kenya, Kiribati, Korea, Kuwait, Lao People's Democratic Republic, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Mali, Martinique, Mauritania, Mexico, Mongolia, Morocco, Mozambique, Nepal, Netherlands, Netherlands Antilles, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Rwanda, Saint Lucia, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Sierra Leone, Singapore, Somalia, South Africa, Spain, Sri Lanka, Sudan, Surinam, Sweden, Switzerland, Syria, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Arab Emirates, United Kingdom, Tanzania, United States, Uruguay, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe

Appendix 2 Containerization Data

Panel A: Countries that containerize by port or rail 1966-1983 (115 countries)

1966	Germany(P)*	Netherlands(P)*	UK(P)(R)*	USA(P)*	India (R)
1968	Australia(P)*	Austria(R)*	Belgium(P)*	Canada(P)*	Denmark(P)*
	France(P)*	Hungary(R)	Ireland(R)*	Italy(P)*	Taiwan(P)
	Spain(R)*	Sweden(R)*	Switzerland(R)*		
1969	Finland(P)*	Yugoslavia(R)	Japan(P)*	Norway(R)*	Portugal(P)*
1970	Hong Kong(P)	USSR(R)	Greece(P)*	Israel(P)	Romania(R)
	Singapore(P)				
1971	Ivory Coast(P)	New Zealand(P)*	Philippines(P)	Poland(P)	Trinidad(P)
1972	Bulgaria(R)	Czechoslovakia(R)			
1973	Bahamas(P)	Brazil(P)	Iceland(P)*	Jamaica(P)	Malaysia(P)
1974	Cameroon(P)	Chile(P)	Colombia(R)	Nigeria(P)	Panama(R)
	South Africa(P)				
1975	Thailand(P)	Honduras(P)	Indonesia(P)	Korea Rep(P)	Peru(P)
1976	Argentina(P)	Benin(P)	Kenya(P)	Mexico(P)	N. Caledonia(P)
	Saudi Arabia(P)	UAE(P)			
1977	Bahrain(P)	Cyprus(P)	Ghana(P)	Iran(P)	Jordan(P)
	Kuwait(P)	Lebanon(P)	Morocco(P)		
1978	Ecuador(P)	Egypt(P)	Tanzania(P)	Haiti(P)	Iraq(P)
	Mozambique(P)	Oman(P)	P. N. Guinea(P)	Samoa(P)	Sierra Leone(P)
1979	Algeria(P)	Angola(P)	China(P)	Congo(P)	Djibouti(P)
	El Salvador(P)	Syria(P)	Neth.Antilles(P)	Nicaragua(P)	Pakistan(P)
	Qatar(P)	Sri Lanka(P)			
1980	Guatemala(P)	Liberia(P)	Libya(P)	Madagascar(P)	Sudan(P)
	Uruguay(P)				
1981	Brunei(P)	Bangladesh(P)	Belize(P)	Costa Rica(P)	Dem.Rep.Congo(P)
	Dominican Rep(P)	Fiji(P)	Guadeloupe(P)	Togo(P)	Venezuela(P)
	Tunisia(P)	Turkey(P)*			
1982	Gambia(P)	Kiribati(P)	Mauritania(P)		
1983	Bermuda(P)	Ethiopia(P)	Guinea(P)	Malta(P)	Myanmar(P)

(P) denotes that the country containerized by port first.
(R) denotes that the country containerized by rail first.
(*) denotes that the country is an OECD country.

Panel B: Countries that do not containerize by port or rail 1966-1983 (30 countries)

Chad	Mongolia	Senegal	Cuba	GuineaBissau
Nepal	Somalia	Bolivia	Eq. Guinea	Guyana
Bolivia	Eq. Guinea	Guyana	Niger	Suriname
Burkina Faso	Laos	Uganda	Burundi	French Guiana
Paraguay	Viet Nam	Cambodia	Malawi	Rwanda
Cen. African Rep	Gabon	Mali	Zambia	Zimbabwe

Appendix: List of Temperature Sensitive Products (TSPs)

To be completed.