INSIDE THE BLACK BOX: A LOOK AT THE CONTAINER*

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The containerisation revolution, despite being centered on a relatively simple technology, did not take over the cargo shipping industry until the 1960s. This paper argues that the timing of its introduction was determined by organisational as opposed to technological factors. This argument is developed by looking at the events leading up to the introduction of containers into cargo shipping. The rapid spread of containers and the role of standards are also considered. Nonetheless, given the nature of finding coherent organisational patterns and complementarities, it is argued that informational externalities were most probably responsible for any delay in the container system's introduction.

Keywords: containerisation, organisational innovation, standards, information externalities, complementarities.

The use of containers in ocean transportation is held to be the most important technical advance in that industry since the coming of the steam engine. Certainly the improvements in output per worker hour have been phenomenal (often reported at over fifty times pre-container levels[1]), although the total cost reduction for carriers is a more ambiguous matter. With such benefits it is perhaps not surprising that, within a decade of its introduction in the late 1950s, containerisation had totally transformed the cargo shipping industry.

What is startling about the extraordinary impact of containers on cargo shipping is the relative simplicity of its technology. At a technical level, it was the concept of loading and unloading cargo in a standardised box that drove the cost savings. And, as will be argued below, the technology for achieving this was available decades before the 1960s. This leaves open an interesting historical question: given the obvious benefits of containerisation and the relative simplicity of its technology, why were containers introduced when they were and not at some earlier point in history?

Prior to the 1960s, most general cargo (i.e., non-bulk cargo - manufactures) was loaded and unloaded using methods not far removed from those practiced by the Phoenicians two thousand years earlier. Virtually all general cargo was transported over water using the traditional 'break-bulk' method. This involved the cargo ship coming along-side the wharf where it was laboriously

* During the writing of this essay I have benefited from helpful discussions with Tim Bresnahan, Paul David, Donald Lamberton, John Roberts, Nathan Rosenberg and Scott Stern. Funding from a Dean's Special Research Grant, Faculty of Commerce and Economics, University of New South Wales, is gratefully acknowledged. Full responsibility for views expressed in the paper lie with me.

loaded with its cargo. The goods were lifted through a small hatch into the large hold of the ship where workers would stack the cargo, in whatever manner was feasible, so it was relatively safe for the remainder of the voyage. Little or no machinery was involved in the process and it often took three weeks or more for a ship to be fully loaded.

An underlying feature of this traditional system was the distinction between the tasks of the shipping company and those of other transport modes. Once cargo was brought to the wharf it came under the control of a separate company who formed a separate contract with the cargo shipper. The advantages of containerisation were to provide the standardisation necessary to divide the transport loading process into self-contained stages (if you'll pardon the pun) and hence, change the nature of task specialisation between companies.

With containerisation, the goods could be prepacked in large weatherproof boxes before even being moved to the port. There they would remain until the containership came to pick them up. Because of their standardised form, the containers could then be easily moved to the ship's side using trucks and hoisted on the deck of the vessel using large cranes that were permanently affixed to the dock. At the other end of the voyage, the containers could be quickly lifted from the ship and whisked away from the port. This process reduced ship time in port from weeks to days.

Containers redefined the loading tasks of shipping companies to the movement of boxes. The remainder of these functions were transferred to firms in other modes of transport or even to the shippers themselves. Therefore, in order to realise the gains for containerisation, new methods of coordination and integration among firms engaged in different modes of transport were essential. The organisational innovations that allowed for this were complex but, nonetheless, they represented a critical component in establishing a viable container system. It was the development of these innovations that marked the beginning of the containerisation revolution.

It is the thesis of this paper, that the innovations that brought about the containerisation revolution were not so much technical as organisational. It was the delay in the conception and implementation of new methods of organising production in cargo haulage that prevented an earlier commercial introduction of the container system. So while the technical advances necessary for containerisation were available, the complementary organisational innovations to make the system viable were only developed much later.

The following sections will begin by describing the initial introduction of containers to shipping and their subsequent spread throughout the industry. This will give an appreciation of the nature of technical and organisational innovations that make up containerisation. Despite the primarily organisational nature of this innovation, because of its shared attributes with technological innovation, there is reason to believe that the introduction of containerisation was delayed. In the final sections, I review the roles of standards and informational externalities in this and conclude that it was the latter that was primarily responsible for any delay.

THE FIRST USE OF CONTAINERS

There seems to be little dispute that the date the containerisation revolution begun was April 26, 1956, and the person responsible was Malcom P. McLean.[2] On that day a converted tanker was loaded with 58 modified 35 foot truck containers and sailed from Newark, New Jersey, to Houston, Texas.[3] The event was unique for two reasons. First, the containers had actually been filled and sealed at the inland warehouses of the shippers. There they were to be loaded on trucks, taken to the side of the ship and lifted, by crane, onto the specially modified deck of the ship until arrival at Houston whereupon the process was reversed. Second, the whole process involved a single contract, rather than a myriad of separate documents to account for each stage of the journey. Indeed, these two features (one technological and one organisational) characterise, entirely, the features which distinguished the container system from its predecessors. A final point to note about this initial voyage is that it required a fraction of the workforce used in 'break-bulk' methods, although this was more than made up for by additional capital outlays. Given its importance, the specifics of this event will be discussed later.

This establishes the date of the beginning of the containerisation revolution. But in order to determine whether this introduction was a timely, one first needs to examine the necessary conditions that had to be met before the innovation was possible. By necessary conditions, I mean those factors that had to be established before containerisation was technically feasible and, at least, partially feasible, commercially.

Even though a container is, in fact, a very large flat-bottomed box, there are important technical features that would have delayed their development until well into the twentieth century. The architecture of a container requires it to have both vertical strength in order to be stacked and horizontal reinforcement so that it could be lifted by crane, heavy contents and all. Thus, any sizable container had to be built from a light but strong substance, ruling out wood or cast iron. The most practicable substance, reinforced steel, only came into commercial production and development by the 1930s, although, in 1911, heavy steel boxes were used in rail transport. As for the cranes themselves, they had been in use for decades before 1956 (the late nineteenth century had seen the development of power cranes) and trucks had been transporting similar containers for years, although the new method did require modifications that allowed the container to be detached from the chassis. Therefore, it would seem that the technological prerequisites for the container method were met well before 1956. As such, one must look elsewhere to find evidence of delayed introduction.

One obvious potential delaying factor, in a commercial sense, would be the possibility of improving the existing technique of production. Indeed, pallets as a means of lifting and storing general cargo had become common before World War Two. Pallets were simply small wooden platforms to which general cargo could be secured and loaded into the ship's hold. Thus, they offered some standardisation and could reduce rehandling of cargo within the ship's hold. Moreover, the introduction of the forklift truck in 1935 allowed pallets to be moved around the dock with ease and also, around inside the ship's hold.[4] Nonetheless, because they had to fit through the hold's hatch, pallets were necessarily small and thus, the entire system remained labour intensive and did not offer much scope for improvement. Larger units were the key to higher productivity.[5]

But the development of larger units encountered difficulties as some initial forays into containerisation attest. In 1929, *Seatrain*, soliciting business from shippers tied closely to railroad cargo, developed a new hold and crane to carry entire rail cars onboard their ships. The system was viable for a small market and lasted until containerisation came. In Europe, the carrying of heavy steel boxes had become commonplace but these varied in dimensions and were relatively small. After World War Two, Leathem D. Smith developed an 8 foot steel cube but encountered difficulties in filling them for both legs of a given route. This motivated him to make them capable of being folded. Nonetheless, the idea was soon discovered to be unworkable because of the rapid physical depreciation of the boxes. In 1949, some carriers were offering containers on their conventional ships with the idea that they could be the last to be loaded and the first off, an advantage in turnaround time for that cargo. Indeed, *Alaska Steamship* introduced collapsible cargo cribs in 1952 and loaded trailers in 1953 all of which improved turnaround time. However, all these containers rarely left the terminal. In addition, capacity was relatively small and did not, in effect, alter or improve the industry significantly.

In order for containerisation to be truly viable and effective, a complete organisational overhaul was required.[6] Indeed, the shipping industry was criticised as being too conservative to envisage such change,

> Although ocean carrier managements were well aware of the technical feasibility of loading land containers on decks of sea-going vessels, they were reluctant to adopt the practice because it interfered with their preconceived notions of how shipping ought to work and with habits and procedures that had evolved over centuries.[7]

Certainly, the idea that there could be vast gains from generating a cargo system that integrated different modes of transportation had been suggested before. To quote Dr. James Anderson talking in 1801,

> Suppose a Railway were brought to the wharves at Bishops Gate Street, all the wagons to be made of one form and size, each capable of containing one ton of sugar or other goods of similar gravity. Let the body of these wagons be put on a frame that rests upon the two axles of the four wheels calculated to move only upon the railroad and let each of these wagons be loaded with goods which are to go to the same warehouse or vicinity. The whole of the wagons being loaded, they are moved forward until they come to the end of the road at which place they should be made to pass under a crane. The crane would lift the wagons upon another truck formed for street use and when emptied to its point of departure.[8]

Such a change required a combination of insight and commitment of the kind that is difficult to generate within an industry. This is, indeed, what *Sealand* under Malcom McLean offered in 1956. Thus, it becomes crucial to describe and evaluate the specifics of that pioneering experiment in containerisation.[9]

McLean was not a ship operator by trade. Rather he had spent twenty years building a trucking company. Upon the realisation that a substantial proportion of his business along the US East Coast came from shippers filling trailers with goods going to single consignees,[10] McLean investigated the possibilities for an integrated transport system.

> It was clear, therefore, that if the means were developed to carry the trucks by ship along the coast, and simultaneously to simplify the paperwork involved in a multimedia system of transportation, at least some of the complexities which bedeviled the interstate movement of merchandise by truck might be alleviated.[11]

But the realisation of the possibilities is a very far cry from actual viability.

In the early 1950s, McLean began systematically gathering knowledge about the feasibility of his idea. Recalling earlier proposals to put entire trailers on ships,[12] the floating garage idea, he organised a research team to examine this possibility. While the East Coast would be a good market for this plan, the economic analysis was not favourable. Although an improvement in port turnaround was projected, the trailers took up too much space and weight on the vessel. The solution, at this point, became obvious — the container would need to be separated from the trailer. Thus, research was directed towards developing a reinforced steel container and a ship to carry them. While exhaustive, this research was relatively short in duration and, thus, reduced the uncertainties that would form the part of traditional research and development.[13] The crucial point about this new direction was that containers were to be viewed as being carried on deck rather than in a hold, eliminating the crucial bottleneck of the hatch size. Since containers on surface transport must be weatherproof by necessity (i.e., to be used with trucks), the sweeping away of the hatch impediment allowed the possibility of large containers to flourish.

There were several problems to be overcome in order to put the plan into place. First, there were legal difficulties. U.S. law prohibited the single ownership of two or more competing modes of transport. But in September 1955, McLean seized an opportunity to sell his trucking company and then proceeded to buy a sea carrier, *Pan-Atlantic Steamship*, thereby, solving the problem of where to get ships with the minimum of expense and legal complications — a factor that could have put the initial experiment back years. McLean then equipped the tankers he had acquired with a special deck that containers could be fastened to. The pieces were then in place for an experiment and demonstration of the kind that Alfred Marshall[14] had emphasised as being a very effective means of communicating the usefulness of an innovation. Thus, after negotiating a series of contracts with trucking companies and checks to ensure that trucks were available at Houston in a coordinated manner, the carriage transaction was drawn up on a single bill of lading. Shippers were particularly enthusiastic about this. In addition, cranes were installed on the ship to make it self-sufficient. Nonetheless, the converted tanker could not carry enough containers to make the initial voyage profitable, losses which McLean accepted as unavoidable start-up expenses.[15] As pilot projects go, however, the voyage was successful. It was sufficiently impressive to warrant further development. This was reflected in an Interstate Commerce Commission report:

> Malcom McLean is pioneering in the integration of sea-land transportation and in the application of the latest technological developments. A man of vision, determination, and considerable executive talent, he is making a valuable contribution.[16]

And as Kendall summarises: "The magnitude of what was transpiring on that cloudy, cool April day lay not so much in the visible scene but rather in the uncounted hours of thinking, experimenting, and establishing the most effective means by which to accomplish that objective."[17]

Of course, McLean refined his operations after this initial experiment. He converted more ships and was able to demonstrate the sustained efficiency gains from containerisation. The hours of ship time in port were reduced from approximately 84 to 14 hours and the workforce required to 42 from a previous 126 people![18] This saved wages and time, and in an industry that thrived on a regular and frequent service, it reduced the number of ships required to maintain this. In the end, McLean had proved the workability of the container system and was able to provide a service that offered greater reliability, less pilferage[19] and claims for losses, a lower number of inspections in transit, fewer contracts, lower damage[20], standardisation with other modes of transport, and the benefits of the inland loading of containers.

THE SPREAD OF CONTAINERISATION

Sealand entered the North Atlantic international route in 1965, and by 1972 most major routes were containerised. Given the difficulties of such a major shift in the organisation of production, the containerisation revolution was remarkably swift. While many intracountry routes were containerised by the mid-1960s, including the introduction of the first specially built containership in Australia in 1964, internationalisation came more slowly. The coordination required in securing simple contracts and the availability of other transport modes, was far greater across countries.[21] Nonetheless, once McLean had demonstrated its feasibility, it took less than a year for other companies to begin to follow suit.[22]

What facilitated this rapid adoption?[23] First, McLean's demonstrations were impressive and influential. For example, by the 1960s, it had been learned that cranes aboard ships were too disadvantageous — they were idle while at sea, too heavy (thus, substituting for cargo), increased the costs of building ships, required much maintenance, and lowered container capacity on ships. Thus, dockside cranes were better and bigger. They did represent a considerable cost, however, but ports were convinced on their merits and found it profitable to install them and charge rents to carriers. This reduced the sunk costs for entry of other carriers.

Second, ports were relatively enthusiastic about converting to a containerised infrastructure.[24] This reaction was critical.

> In the purest concept of integrated through transportation ports are just a bloody nuisance. At best they are a pause interrupting the smooth continuous movement of cargo from buyer to seller. At worst they are a bottleneck where the mass of expense and delay is gathered by our otherwise rolling stone... I do not mean to sound too dogmatic about ports. I am personally involved in operating my own and other peoples, but I do

> feel that we have to get rid of the idea that a port is an industry which is entitled to exist in its own right. Transportation itself is a service and only has the right to exist so long as it is serving industry in the most efficient and economic way possible. Ports are a service to transportation in other words a service to a service.
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> Capital intensive, large and impressive though they may be it is only in this context that ports should be judged.[25]

This sunk cost of transformation was not borne by ship owners, at least not immediately. Thus, a potential impediment to the effectiveness of containerisation was removed quickly.

Third, the competitive pressure from *Sealand* and other early movers into containerisation was crucial. This was, in effect, non-price competition in that it was primarily the quality of service that was improved. As pointed out earlier, containers offered reduced damage, reduced pilferage, less packaging, a lower 'paper barrier', and simplified rate making.[26] In terms of the total cost of transporting goods, there were clearly massive savings with the container system. Freight rates, themselves, however, have risen steadily — highlighting the non-price nature of the competition. But the competition was real and some companies found attempts to modify their break-bulk methods to incorporate containers unprofitable, which reinforced the notion of overall organisational change.

Fourth, the world trade volume in general cargo was increasing rapidly since World War Two. Thus, a buoyant demand and greater market extent, assisted in justifying the large sunk costs in switching to containerisation.

Fifth, containerisation requires far more than its predecessor in the way of detailed information regarding cargo types, ownership, and destination so as to assign proper containers and to keep track of the contents of those containers. In the initial voyage of the *Ideal X* in 1956, the information about the 58 containers was collated and kept by hand. However, as the fleet grew and the number of containers to manage — across the U.S. and other continents — grew into the thousands, the need for more efficient information processing was realised. The development of operations research and then computers were crucial ingredients in the success of containerisation and aided in its effective spread. McLean introduced computers quite early on, again indicating his willingness to abandon traditional methods. And computers have continued to grow in importance with structural changes in the industry (see below).

Finally, by far the most important driving force for change was the same which motivated the initial movement towards new methods of cargo handling — the changing factor price and unit cost structure. Labour costs had been rising steadily since the War while profits were falling. Meanwhile, as a result of extensive exploitation early in the twentieth century, port-side workers had organised themselves into powerful labour unions which had bargained for other improvements in work quality — another cost associated with labour. Thus, shipping companies viewed a reduction in reliance on labour as in their primary interest. And the threat was realised by the unions early.[27] Containerisation offered a means of securing this goal. As has already been noted, it was highly capital intensive, and it required a more highly skilled workforce. This being the case, old labour problems could be swept away in the containerisation wash.

But while these forces drove the spread of containerisation, there were impediments. Not surprisingly, the resistance of labour unions was considerable. An attempt in 1959 by Grace Lines to establish a container service to Venezuela was thwarted by a refusal of longshoremen to unload the cargo. The change was given up with the comment, "[t]he concept was valid, but the timing was wrong."[28] In order to smooth the transition to containerisation, the Pacific Maritime Association on the West Coast negotiated the establishment of a special fund for modernisation and mechanisation.[29] The fund, financed by the Association, gave benefits to older workers to retire early. Indeed, some negotiations resulted in a per container fee being paid to workers.[30] Once again this indicated the high motivations of ship operators to facilitate the change to containerisation.[31]

A shift in technique is not without cost — substantial cost. As already indicated by the example of *Sealand*, containerisation was not cheap. Between 1958 and 1973, more than $7 billion had been invested in containers and ships, and this, at a time when carriers had just invested in new 'break-bulk' vessels. This sent many smaller operators bankrupt. In fact, this investment, under competitive pressure, brought vast over capacity to the industry. Because containerisation improved port turnaround, to maintain a frequency of service, twice as many ships as could be justified financially had to be built. This caused such difficulties that companies formed consortiums on may routes. These consortiums distributed the traffic among member operators so that service frequency over the route was maintained, but not by single companies. This required government approval and a coordinated management. In an industry that had a long history of corporate cooperation and collusion, in most cases, this new organisational arrangement was successfully achieved.[32]

In this section and the last one, it has been shown that the technical prerequisites for containerisation were met well before 1956. Hence, the main innovation in 1956 was organisational as opposed to technical. In addition, the spread of containerisation was remarkably swift after 1956 indicating that McLean's experiment resolved the critical features that made the container system commercially viable and that these achievements were clearly understood and replicated throughout the industry. This, however, leaves open the question of whether the introduction of containers in 1956 was timely. In the next two sections, I will evaluate two explanations of possible delay — the role of standards and informational externalities — in light of the descriptions presented thus far.

STANDARDISATION

An inability to forecast or agree on a standard has been held to be a reason for delayed introduction of a technology. Such a conclusion is echoed throughout the growing (theoretical and historical) literature on the economics of standardisation.[33] As has already been noted, a hallmark of the container system was the ability to transfer containers across modes of transportation and, indeed, between different shipping companies. It is, thus, of importance to consider the emergence of standards and its role (if any) in making containerisation commercially viable.

The shipping cargo industry showed tendencies towards unitisation throughout the twentieth century. The developments of palletisation and the use of smaller metal boxes facilitated dock and hold mobility of cargo, and the safe storage of cargo. However, the initial foray into containerisation in 1956 saw the importance of standardisation of a different kind for it dealt with complementarities between transport modes rather than within a production process. Thus, McLean was driven by the use of the 35 x 8 x 8 foot container used in trucking when he adopted containers of like dimensions. This act, being one of entry into a market, required no coordination with other carriers, only with the trucking industry of which McLean had inside knowledge and experience. The point to be noted here was that the container system was viable before any common standards came to be set upon.

Indeed, it was not until July 1967 that the International Standards Organisation (ISO) agreement was signed (although the subject had been discussed for six years). And despite *Sealand* and *Matson's* dominant share of the container shipping market, the standards agreed upon were the 10, 20, 30 and 40 foot length containers (cf. *Sealand* had a 35 foot and *Matson* a 24 foot container), with the 8 foot width and height.[34] The yardstick of measurement became the 20 foot container. Of course, the ISO agreement was only a recommendation and carriers were not compelled to adopt the standard.[35]

So what motivated the eventual standards? *Sealand's* 35 foot container was designed to be exchanged with trucks only, *Seatrain* used a 27 foot container so that two could be placed on 55 foot railroad flatcars, and *Matson Navigation Co.* found that the 24 foot container most suited the trucks on Hawaiian roads. Nevertheless, the Europeans learned that 10, 20 and 40 foot containers suited their containerships designed for 40 foot containers. This allowed them to optimise on ship capacity and transport mode variability, unlike their American rivals which concentrated on more specialised intermodal interchange. Thus, in hindsight, it is unsurprising that the flexible standard won the day over already existing investments. The evolution, however, was not without conflict.[36]

The importance of this flexible standard is reinforced by later developments with respect to the ownership of containers. Although the recommendations of the ISO must have been important, what eventually forced the American ship-owners to adopt the European standards was the issue of container interchangability between carriers. The pioneer containership operators had to buy their own containers and they loaded their ships with those containers only. There were difficulties in this system. There were lost boxes, and given the expense of containers, there was a powerful incentive to trace them. Some were found in use as warehouses for consignees who did not want to empty the container immediately. Some were used as stores. This was a high cost for carriers. Moreover, the problems of returning containers were also inconvenient for consignees — better to hold onto a container and then refill it with other goods than have to go through the process of returning and receiving an empty container. Thus, there was a market niche for rental companies to lease containers — another organisational innovation which facilitated the effectiveness of the container system. These companies, for obvious reasons of flexibility, adopted the ISO standards. And ship-owners, faced with the large capital costs of containers, and the need for interchange between carriers, used the leasing companies. Also, leasing companies could economise on information in keeping track of containers since there was little need for physical relocation to other assets (i.e., ships). Indeed, by the 1980s, two thirds of containers were owned by such companies and the ISO standards were set virtually in stone.

It is an interesting feature of the public good aspect of a standard that a change in asset ownership occurred. The uncertainty regarding the potential use of an individual container motivated both a standard and a 'neutral pool' for use by carriers and others. This helped overcome potential brittleness[37] in the container system.

EXPERIMENTATION AND INFORMATION

So what remains of the issue of the timeliness of the introduction of containerisation. In this paper, we have seen that containerisation was technologically feasible well before 1956: the legal and collusive barriers to the new method were few, port operators welcomed developments with open arms, the resistance of labour unions was quickly overcome, and modifying innovations to the 'break-bulk' system were exhausted. In addition, coordination problems due to standardisation factors did not effect the initial use of containers. Thus, *prima facie*, there seems to be little evidence supporting the untimely adoption of containers. There is, however, an additional theoretical reason accounting for the possible delay of the introduction of containerisation: the informational externalities associated with experimentation to determine whether a container system was cost effective.

The discussion above has shown how establishing a container system involved much more than the use of a box in cargo haulage. To make this commercially viable, new ships needed to be designed, alternative contractual arrangements had to be devised, and the information structure of shipping organisations were changed including greater integration with other transportation systems. All of the facets of the container system were mutually complementary with the introduction of one element raising the marginal returns to introducing the others. This is indeed why the piecemeal earlier attempts at introducing containers failed. Each changed one element of the original system, neglecting the others (in particular, the organisational aspects) and hence, failed to reap the full returns from containerised cargo.

The fact that the container system involved the fitting of so many distinct elements into a coherent pattern suggests another possible reason for the delayed introduction of the system: the difficulties associated with finding a commercially viable system. When one is dealing with many complementary choice variables, it is a safe bet that determining the levels of each of them that will lead to a higher returns than a previous, functioning system will be very difficult and not obvious. Thus, experimentation is required to find the pattern of those variables that will fit, that is, that will not neglect to change some key variable. Such experimentation is costly in terms of both time and resources and hence, it is possible that the perceived delay in container adoption was due to the delay in locating a commercially viable container system.

The mere fact of having to discover an appropriate configuration of the elements of the container system does not in of itself offer an explanation for sub-optimal delay. However, the experimentation process is not one that necessarily took place within one firm. The experiments of firms were observed by others. Recent theoretical work suggests that such interactions among firms in their search for coherent patterns provides an argument as to why the amount of experimentation was sub-optimal. The models of King, Caplain and Leahy, and Bolton and Harris[38] suggest that when the search or experimentation results of one agent can be observed by other interested agents, there is an incentive for agents to free ride on the information generated by others. Such information externalities mean that experimenters fail to take into account the usefulness of information produced for others and that agents will reduce their experimentation in anticipation of the information being produced by others. Both of these effects lead to insufficient experimentation and hence an underproduction of information. Therefore, the existence of information externalities in searching for a viable container system is a reason for delay in its eventual adoption.

The plausibility of the argument that information externalities led to insufficient search or experimentation in the case of containers rests on three factors: (1) when experiments were undertaken their results were freely observable by others in the industry; (2) that the experiments themselves were costly; and (3) that to switch to a new system involved irrecoverable costs. While the importance of (1) is clear, if (2) were not present then it would be easy for all firms to experiment continually to find a better system and, hence, they would do so at the maximal rate. The rationale for (3) is similar to that of (2). If switching to the new system were not costly, then experimentation could take the form of switching systems and, hence, would proceed at the maximal rate.

For the case of containerisation, there is considerable evidence that conditions (1) and (2) were satisfied. McLean's and other earlier demonstrations were public information and were reported in both trade journals and daily newspapers. And when the system was proved viable, the system was understood and copied throughout the industry. Moreover, as McLean's own demonstration shows, there was considerable cost in conducting pilot experiments into the commercial viability of the container system. Not only was there research and development required, but the refitting of a ship and the negotiation of an intermodal contract.

There is also evidence that (3), the costs of switching to the new system, were high. Savings in the marginal costs of service (or gains through improved service quality) have been matched by increases in fixed costs (themselves a type of switching cost). These fixed costs arose because of the need to convert or build ships with a specially designed deck for containers. Thus, overall containerisation has not provided the initially anticipated total reduction in the costs of shipping companies. "Even on the superficial side, containers have not proved to be such a cost saver as was first thought."[39] Also, profits have remained relatively low because of the massive capital investments required for containerisation.[40] Finally, even though the cargo service has been improved greatly in regularity and speed, freight rates have risen steadily.

> Where the containerization has been carried out, a reduction in freight rates has not

occurred; the cost of capital which has been substituted for labour is very substantial. The hope is that the containerization will halt the trend of soaring freight rates, and not that it will really turn this trend downwards.[41]

The benefits of containerisation came from an improvement in the quality of service. Thus, there was a saving in terminal costs[42] but no reduction in the costs at sea (if anything containerships were more expensive than 'break-bulk' ships).[43] This factor is also supported by evidence presented by Jansson and Shneerson[44] indicating differences in labour costs at sea between systems (e.g., each has an average crew of around 25). And all the above costs do not reflect fully the large investments that had to be made in containers themselves, at least before leasing companies were developed.[45] In addition, the cost structure of the container system reduced the proportion of variable costs to a considerable degree, with most containing a large sunk cost element. This not only diminished the possibility of switching back to an alternative mode of production but reduced the flexibility of companies to respond to supply-side shocks.[46]

Therefore, the history of containerisation provides substantial evidence that the conditions for information externalities leading to delayed introduction were met. What is interesting in the container case is that the information that was underproduced was organisational, not technological, in nature. Such organisational innovations are of considerable importance in many industries and like technological ideas, the case of containerisation shows that they can be analysed fruitfully from an informational viewpoint.[47]

CONCLUSION

This paper has highlighted that focusing the organisational as well as the technological aspects of an innovation can be of critical importance in understanding the introduction of a system into production and its subsequent spread throughout an industry. It has been argued here that the containerisation revolution resulted from key innovations in organisation (the integration of firms across modes of transport by contractual changes and the re-allocation of tasks among firms) that complemented known technological developments to create a commercially viable system. The case of the container represents an ideal case for this type of analysis because of the relative simplicity of the technological advance required and the relative complexity of the organisational one. It thus exemplifies the complementarities between technological change and organisational design.[48]

This paper has also shown that in analysing an organisational innovation, perspectives useful for technological innovations are very useful. In particular, an organisational innovation can in this case be regarded as the production of an idea or piece of useful information.[49] Therefore, it possesses many of the economic characteristics of information such as nonrivalness and nonexcludability. Hence, as was shown here, there is reason to suppose the organisational innovation like technological innovation will occur at a suboptimal rate.

However, the very simplicity of the technological innovation in the container case, the ease with which its complementary organisational innovations could be understood, mask the greater complexity that surely exist for other industries and innovations. The division between the technological and organisational is not so clearly defined and the features that characterise a successful organisational form are not so readily classifiable. Thus, considering the organisational dimension of technological progress remains a fruitful area for future research.

NOTES AND REFERENCES

1 J.O. Jansson and D. Shneerson, *Liner Shipping Economics*, Chapman & Hall, London, 1987, p.25.

2 There are suggestions that the U.S. military was also a pioneer in the use of containers. Small containers were used by UN forces in Korea in 1952, specifically to improve cargo carriage (R.E. Dittmer, 'Distribution Cost Benefits to Shippers from Intermodal Transport,' in *Intermodal Transport: Its Effect on Rates and Service*, Oregon State University, Corvallis, OR, 1969, pp.59.) But this was really not on a scale which could properly be described as containerisation. The boxes were simply not large enough. There was some linkage between military experience and civil development in that some former military personnel did play a role in the development of containers and, more importantly, containership design.

3 There is some dispute as to the name of the ship. Kendall refers to the *Ideal X* whilst others (e.g., Whittaker) refer to the *SS Maxton*, which according to Kendall was not used on the original voyage. See L.C. Kendall, *The Business of Shipping*, 4th ed., Cornell Maritime Press, Centreville, 1983, p.178; J.R. Whittaker, *Containerization*, 2nd ed., Wiley, New York, 1975, p.3.

4 Within two years the hand truck was completely driven from most wharves by this development.

5 In addition, because of the unpredictability of rain, cargo could not lie for long in the open and thus, had to be stored in dockside warehouses. Thus, the container, which was of necessity weatherproof in order to lie efficiently on the deck of the ship, also solved this problem of the break-bulk system.

6 This view was confirmed by a later National Academy of Science report in 1959 which argued that hybrid systems (with both break-bulk and container systems on a single ship) would not be economically viable. See S. Gilman, 'Investing in Deep Sea Liners: Container, Ro-Ro or Conventional Technology,' in I. Ryden and C. von Schirach-Szmigiel, *Shipping and Ships for the 1990's*, Handelschogskolan I Stockholm, Stockholm, 1979, pp.228-45.

7 G. Muller, *Intermodal Freight Transportation*, 2nd ed., Eno Foundation for Transportation, Westport, 1989, pp.13-4.

8 Anderson quoted by M. Wronski, 'Containerisation: Its corporate impact,' *Cranfield Research Papers in Marketing & Logistics*, No.4, Bedfordshire, 1974, p.4. This remarkable statement 170 years prior to the introduction of containers was cited by Wronski although he gives no additional source.

9 Much of the detail of this account relies upon the excellent descriptions of Kendall, op.cit., Chapter 10. See also, British Transport Docks Board, *Containerization: The Key to Low-Cost Transportation*, report by McKinsey & Co., Ltd., 1967; R.O. Goss (ed.), *Advances in Maritime Economics*, Cambridge University Press, Cambridge, 1977; K.M. Johnson and H.C. Garnett, *The Economics of Containerisation*, George Allen & Unwin, London, 1971; S. Joy, 'A Study of the Economic Influence of Containerisation on Transport Systems,' *ECMT Round Table 21*, Economic Research Centre, Paris, 1973; E.T. Laing, *Containers and their Competitors: The Economics of Deep Sea General Cargo Shipping in the 1970s*, Marine Transport Centre, University of Liverpool, Liverpool, 1975; H.B. Meyers, 'The maritime industry's expensive new box,' *Fortune*, November, 1967, pp.152-4, 194; J.C. Nelson, 'The Economics of Intermodal Transport,' in *Intermodal Transport: Its Effect on Rates and Service*, Oregon State University, Corvallis, OR, 1969, pp.1-40; OECD, *Developments and Problems of Seaborne Container Transport*, 1971; E. Rath, *Container Systems*, John Wiley, New York, 1973; S.G. Sturmey, 'Barrow, Containers and Morecambe: A Polemic on Regional Planning,' *Shipping Economics: Collected Papers*, Macmillan, London, 1975, pp.122-32; S.G. Sturmey, 'Trends in Shipping Economics 1966-2066,' *Shipping Economics: Collected Papers*, Macmillan, London, 1975, pp.155-64; K. Jacob, 'A Look at the Container Shipping Revolution,' *Traffic World*, July 6, 1981, pp.60-3.

10 Which was an important prerequisite in providing a sufficiently large market for an intermodal system, at least initially. Even today, the success of containerisation hinges on single shippers, at least, being able to fill containers.

11 Kendall, *op.cit.*, p.179

12 In 1951, TMT actually did something similar when it took converted truck bodies as cargo from Miami to Puerto Rico. See S. Gilman, *The Competitive Dynamics of Container Shipping*, Gower, Liverpool, 1983.

13 see Kendall, *op.cit.*, for more details of this process

14 A. Marshall, *Industry and Trade*, Macmillan, London, 1920, p.307.

15 *Journal of Commerce*, August 18, 1955.

16 *New York Times*, Nov. 28, 1956

17 Kendall, *op.cit.*, p.183. Thus, there is something to the following kinds of statements which reoccur through the literature: "What is of paramount importance is to realize that without the combination of practical wisdom, commercial genius, and unwavering audacity, the events which today are described as the container revolution *might not have occurred.*" (Kendall, *op.cit.*, p.202, the italics are mine) Such statements are too strong, in my opinion. While McLean deserves full credit for the acceleration of the container revolution, it is too much to say that it might not have occurred at all. As discussed below, the rising relative labour costs would have, eventually, forced a switch to a more reliable capital intensive system.

18 *New York Times*, Nov. 23, 1958

19 This was a major problem on waterfronts prior to containers. It was estimated that at one time 20% of all whiskey shipped through New York disappeared (Whittaker, *op. cit.*, p.46). Also see W.H. Penrose, 'The Impact of Intermodal and Coordinated Transport on Ocean Carriers,' in *Intermodal Transport: Its Effect on Rates and Service*, Oregon State University, Corvallis, OR, 1969, pp.45-6.

20 Even though, in the beginning, containers fell off deck occasionally, and condensation within containers caused some damage.

21 One such impediment was obviously customs inspection which diluted the advantages containerisation afforded in the way of reduced paperwork (H.K. Strom, 'Containerization: A Pandora's Box in Reverse?' *Transportation Journal*, 12, Winter, 1972, pp.46-57.). Some problems have been addressed, however. For example, provisions were made for the temporary importation of containers for spare parts and repairs with no duties or charges, and the registration of containers with International Containers Union in order to provide data for identification (A. Jatosti, 'Containers: A technological revolution in transport,' *Review of Economic Conditions in Italy*, 26, November, 1972, p.480.)

In addition, international trade involves a greater cost in realising the intermodal advantages of containerisation. Since direct coordination with transport companies at both ends of the route are required, all associated communication costs are greater across continents.

22 E.T. Laing, 'Containers, pallets or lash? The economics of general cargo shipping,' *QER Special* No.13, EIU, London, 1973.

23 Especially given a container shortage in the 1960s.

24 It is an interesting and open issue why ports were so enthusiastic about making way for containerisation. The potential competition between ports was almost certainly a factor here. However, the inducement to save labour in the face of rising relative wages and non-arms length interactions between ports and ship-owners could have played a role. This issue represents a significant avenue for further research.

25 George Holloway, Managing Director of Shipowning Co., quoted by F. Suykens, 'Containerization, the Unit Load, the Combination Ship,' *Economisch En Sociaal Tijdschrift*, 23(5), October, 1969, pp.455-6n.

26 Strom, *op.cit.*, p.51-2.

27 Suykens, *op.cit.*, p.456.

28 *ibid.*

29 Strom, *op.cit.*, p.48.

30 L.W. Shaw, "Containerization - Present and Future," in G.L. Gifford, *Distribution with Imagination*, Tucson, University of Arizona, 1962, p.21.

31 Almost Marxian-like motivation especially considering the dual forces of competition and technology. See Barry Jones, *Sleepers, Wake! Technology and the Future of Work*, 2nd ed., Oxford University Press, Melbourne, 1983, on displacing employment trends of technology.

32 See Gilman, *op.cit.*; Kendall, *op.cit.*; and E.T. Laing, *Containers, Conferences and Competition*, The Economist Intelligence Unit, London, 1984, for more details regarding these arrangements.

33 Paul A. David, 'Clio and the economics of QWERTY,' *American Economic Review*, 75(2), May, 1985, pp.332-7; Paul A. David, 'Some New Standards for the Economics of Standardization in the Information Age,' in P. Dasgupta and P. Stoneman (eds), *Economic Policy and Technological Performance*, Cambridge University Press, Cambridge, 1987, pp.206-39; Paul A. David, and Edward Steinmueller, 'The Economics of compatibility standards and competition,' *mimeo.*, CEPR/Stanford, 1992.

34 Height was still under negotiation at this time with some suggestions that greater height be allowed for. Nine and a half foot high containers are now part of the sanctioned standards.

35 To use David and Steinmueller's, *op.cit.*, terminology the container standard is a compatibility standard which was the result of market mediated forces. Initially, it was an unsponsored movement on the part of individual ship-owners which became sponsored by the ISO.

36 Kendall, *op.cit.*, p.215.

37 I use the term "brittleness" in the sense implied by Paul Milgrom and John Roberts, *Economics, Organization and Management*, Prentice-Hall, Englewood Cliffs, 1992, Chapter 4. Their notion is supposed to capture an important flexibility and stability character in organisational design.

38 Stephen King, 'Search with Free Riders,' *Journal of Economic Behavior and Organization*, 1993, (forthcoming); Andrew Caplin and John Leahy 'Miracle on Sixth Avenue: Informational Externalities and Search,' *Discussion Paper*, No.1665, Harvard Institute for Economic Research, 1993; Andrew Caplin and John Leahy, 'Mass Layoffs and Unemployment,' *Discussion Paper*, No.1666, Harvard Institute for Economic Research 1993; Patrick Bolton and Chirstopher Harris, 'Strategic Experimentation,' *mimeo.*, Oxford, 1993.

39 Wronski, *op.cit.*, p.5. Similar accounts of over-optimistic expectations are reported by Laing, *op.cit.*, 1973; Kendall *op.cit.*, p.207; and G. Muller, *Intermodal Freight Transportation*, 2nd ed., Eno Foundation for Transportation, Westport, 1989.

40 Suykens, *op.cit.*, p.461.

41 Jansson and Shneerson, *op.cit.*, p.25.

42 Gilman, *op.cit.*,1979, p.238.

43 Gilman, *op.cit.*, 1979, p.241. Indeed, because containerships spend relatively more time at sea, fuel costs play a greater part in their cost structure (Muller, *op.cit.*).

44 Jansson and Shneerson, *op.cit.*, p.16.

45 Strom (*op.cit.*, p.52) reported that for every 1,000 containers at sea, 3,000 were needed at maritime terminals for pick-up and use on inland feeder lines. In fact, this fact prompted Strom to anticipate the emergence of leasing programs years before their coming.

46 Kendall, *op.cit.*, p.207.

47 For an interesting discussion of the role of experimentation on organisational forms see Nathan Rosenberg, 'Economic Experiments,' in *Exploring the Black Box*, Cambridge University Press, Cambridge, 1994, pp.87-108.

48 Such characterisations are not new to the history of shipping; see Douglass C. North, 'Sources of productivity changes in ocean shipping 1600-1850,' *Journal of Political Economy*, 67, 5, 1968, pp.953-70.

49 Paul Romer, 'Idea gaps and object gaps in economic development,' *Journal of Monetary Economics*, 32, 1993, pp.543-73.