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THE DETERMINANTS OF SHIPPING RATES: A NORTH ATLANTIC CASE STUDY

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Abstract

This paper explores the factors that influence the rates charged by liner shipping firms on the North Atlantic. In particular a case study is presented looking at the effects of various cost and demand variables on standard (dry van) container rates. The study makes use of a unique data base to examine the role of factors such as cargo weight and nautical distance as determinants of the prices paid. The nature of the customer (freight forwarder, consignee or shipper) is also examined to reflect the influences of requirement variations on pricing in addition to that of the commodity cost of provision. The study takes account of the direction of the trade (i.e., eastbound vs. westbound) as a further influence. The study uses basic statistical procedures to consider variability of rates and to relate these to the set of explanatory factors. No previous studies of conference pricing have included a customer type variable.

Literature Review

The pricing of liner shipping has been a major issue since the UK's Royal Commission on Shipping Rings reported in 1909. The majority of studies have examined how conferences set prices and have taken one of two approaches: they either focus on how conferences should be regulated or, by reviewing published tariffs, attempt to draw conclusions about the influence of relevant variables upon the published prices. This paper is written in the latter vein.

In liner shipping it has long been established that differential pricing is beneficial to both shippers and the line. As explained by Heaver (1977), commodity D is not profitable to carry, and B and C would not move if the average cost were charged but will if some variant of differential pricing is used (Exhibit 1). A detailed look at the Australia–Europe Conference by Zerby and Conlon (1978) produced a breakdown of rates which generally confirmed that the low value-bulk cargoes (i.e., ores and metals) that are carried at (or sometimes slightly below if ballast is required) the average incremental costs of loading and unloading, while high value products are carried at considerably higher rates with a ceiling imposed by competition from air transport. Such a pricing approach enabled carriers to broaden the service beyond the levels which would be carried under a simple FAK pricing structure.

Exhibit 1: Liner Pricing Based on Relevant Costs

Commodity	Ability to Pay	Average Cost Per Unit	Incremental Cost
A	2.50	2.22	2.22
B	1.80	1.95	1.60
C	1.50	1.82	1.30
D	1.00	1.75	1.10

Source: Heaver (1977), page 35. (Not all data reproduced but demand, ship size and ship cost were). This table also appears in Heaver (1982).

Early liner pricing studies, such as O'Loughlin (1967) and Bennathan and Walters (1969) focused on port/distance determinants and elasticity of demand respectively but their findings have little relevance to the containerization era. Subsequent studies can be considered more relevant. Bryan (1974) statistically examined the impact of unit value, stowage, distance, quantity shipped, conference membership, and number of non-conference competitors on ocean-going freight rate variations for outbound Canadian liner cargo in 1969. After performing separate and combined regression analysis models, Bryan concluded that while "conferences and monopoly liners" discriminated upon both unit value and bulk, variations based on distance, quantity shipped and competition although significant were less pronounced. As with many of the other early studies, liner prices were evaluated on a per ton basis rather than a per TEU basis.

Heaver (1973) refuted O'Loughlin's research; he examined four independent variables in an effort to identify the determinants of freight rates—the stowage factor (in cubic feet per long ton), the value of the goods (dollars FOB per long ton), total quantity shipped per year (dollars FOB for each commodity annually i.e., aggregate not by individual firm) and the requirement for refrigeration. The tariff is the one published, which may not be the one paid, and the value was taken from trade statistics and not the individual company paying the freight bill. The study explained 75 to 92 percent of the variation in price paid and Heaver (1973) concluded that the rate is not set at "all the market will bear" but at a cost-determined rate in which the stowage factor is the fundamental determinant—reflecting loading and discharging costs as well as vessel capacity—and some recognition is given to the unit value of the commodity carried. To be sure that loading and discharging costs do not obscure the factors influencing the rate paid on the ocean leg, the study presented in this paper excludes loading and discharging costs, and uses the **actual price paid** taken from invoice summaries rather than the tariff published, an important difference from any other liner pricing research.

Deakin and Seward (1973) examined the value of the product carried, tonnage, stowage, hazardous nature, need for refrigeration, "individually priced items" or classed items, and a variable for other items. They concluded that demand factors accounted for about two-thirds of pricing variation while cost factors accounted for the remaining one-third and that buyer knowledge of market prices is limited. This last is very different now, not just for a given route but on a world wide basis, due to the globalization of the business of the buyer.

While several studies found that the stowage factor and the unit value of the commodity to be the most important factors accounting for variations in liner freight rates, Schneerson (1976) concluded that demand played a significant role in establishing rates and that "misconceptions of costs as reflected in the use of the stowage factor in establishing rates is perhaps the practice in most urgent need of rectification in the pricing system."

Wei *et al.* (1984) used published tariffs to analyze freight rates on the North Atlantic and did not follow Schneerson's (1976) advice. Their results showed a positive correlation between the conference tariff, the unit value, the stowage factor, and the dummy variable for temperature-controlled containers. The particular problem of estimating the value of the cargo and the stowage factor persisted even though it was clear that the market was in the throes of change and that stowage is only relevant if the ocean leg is fully utilized, not common in the climate of excess capacity experienced in the 1980s. The problem with including cargo value is further discussed by Sjostrom (1992) as a confounding factor.

The deficiencies of most studies using published rates is they do not reflect that individual lines within the conference may opt to change the rate (Jansson and Schneerson, 1987). In a study comparing a conference index with an individual line's freight index, they concluded that the conference index showed much greater rate stability and was different in both direction and magnitude to the actual paid. Evidence also showed that changes in conference rates did not reflect "across-the-board" changes but were route-specific, e.g., they behaved according to the specific conditions prevailing on a particular route. Concluding that published rates are a poor guide to the actual development of rates, they believed that such rates should be interpreted as "ceiling" or "maximum recommended prices." The need to look at actual prices paid is clear.

Furthermore, Jansson and Schneerson (1987) predicted that the stowage factor no longer carries "any particular significance." The correlation between dependent variables was strongest between weight and container size, not surprising as very heavy products cannot exploit the cube benefits of a 40' over a 20' container. They concluded that the reason for the strong stowage factor influence on freight rates is due to freight rates being the sum of the direct handling cost plus a "contribution margin" based on the principle of charging what the traffic will bear. This review indicates the need for a study which isolates the ocean leg from terminal and inland charges as well.

There have been few studies which have compared conference prices to non-conference prices on the same route—one exception being Bryan (1974). The flurry of activity examining liner pricing diminished in the early 1980s—with the exception of Wei *et al.* (1984) and Jansson and Schneerson (1987), both of which made valuable contributions to the literature—only to be revived by the Federal Maritime Commission (1989) and Sjostrom (1992) along with the current debate about how conferences are regulated in the U.S. and the European Union, particularly with respect to the TransAtlantic Agreement.

This literature review has highlighted the prevailing rationale for liner prices and the debate which existed in the 1970s. But the marketplace has changed. Changes in technology have restructured the marketplace for liner shipping over the past decade, particularly broadening the hinterland of specific

routes and forcing carriers to contemplate hardware-sharing on a large scale. The "product" has changed from predominantly breakbulk to a relatively anonymous box even for traditional bulk commodities. Management techniques have certainly changed with the professionalization of ship management and, finally, the non-conference share of liner shipping has grown to be significant. Competition from tramp and neo-bulk carriers continue to set a ceiling on how high prices for the transport of resource-based shipments may go before shippers switch and the availability of air cargo continues to influence the relevant range for finished goods with high-value, low-density characteristics. The argument about whether rates are cost-based or value-based appears less relevant. Carriers have better information on costs and buyers have better information on prices and their market options.

Assuming for the moment that conferences allow price differentiation by shipper, this study will consider the possibility that current pricing already includes such differentiation. As seen in Exhibit 1, price discrimination can result in more goods being traded because of cross-subsidization. Also price differentiation is possible because some buyers are prepared to pay for the provision of differing levels of service and therefore encourage this type of pricing behaviour on the part of transport suppliers. But there must be a perceptible difference in service for the strategy to work.

In summary, the majority of liner pricing studies have focused on the macroeconomic issues and the regulation of liner shipping conferences. Very few have focused at the micro-economic level and the effect of liner membership on the pricing strategies of the firm. The few micro-economic studies have been based on published tariffs and not the price actually paid, and none have contemplated whether or not prices have been influenced by the type of customer seeking the service. In particular, they fail to address the question facing many liner conference members: is it appropriate to abandon commodity-based tariff systems and move to a freight rate structure reflecting different service levels? Where such service level pricing is deemed inappropriate by regulatory agencies, are there other pricing strategies possible? This paper intends to provide additional information to assist liner shipping firms in addressing these questions but does not go so far as to answer them. That is a strategic planning problem to be solved by the individual firm.

Price Differentiation—The Potential

One possible new approach to pricing is some variant of yield management—a strategy which focuses on isolating the high and low price markets and differentiating the product enough so that the low price version is unattractive to the high price market thereby minimizing the probability of revenue dilution. Unlike the classic economic model of price discrimination where management increases revenue by charging different groups of customers (differentiated by their price elasticities) different prices for the *same product*, some qualitative or other form of product differentiation is involved in yield management. This requires some means of isolating customer groups, for example, by the provision of special services demanded by one group and not another. (For a more detailed discussion of the principles, see Brooks and Button, 1994.) Therefore, from one point of view, it is worthwhile determining if customer type is a significant factor in existing liner prices. From another, it has been shown that

different types of customers have different needs (Brooks, 1993) and there may be the potential to extract greater revenue without an equal or greater rise in costs if an alternate pricing system is used.

Methodology

The research data presented here were collected from the manifests of four sailings—two Eastbound and two Westbound on the North Atlantic. On this route, conference carriers easily carry non-conference cargo, and therefore within the same vessel identical cargoes may bear different prices for the ocean leg. The conference structure limits pricing latitude while the non-conference cargo may be carried at whatever price the carrier is able to negotiate. The manifests chosen had a mix of conference and non-conference cargo and took place within a three-week period in 1990, prior to the implementation of the rationalization agreement of May 1991 and the attendant slot-charter arrangements between the conference operators in the Canadian trades.

For each shipment, the data collected comprised the sailing (1 of 4), the direction (eastbound or westbound—EB or WB), the number of containers in the shipment, length of container (20' or 40'), the type of container (dry van, reefer, other), port-to-port combination for the ocean leg (later converted to nautical miles), the ocean tariff actually paid (in both its original currency and USD equivalent), the commodity classification (2-digit SIC), the weight of each container (in kilograms per TEU), and the conference/non-conference status. (A TEU is a 20' Equivalent Unit.) Collecting only the tariff for the ocean leg stems from the fact that most carriers merely pass the other costs along; although the shipper buys based on a door-to-door price, the carrier has only nominal control over this part of the container's journey. From these data, the TEU for each shipment was calculated, as was the tariff in USD per TEU using the exchange rate employed for accounting purposes (the *Financial Times* published interbank rate for the date of sailing) for those shipments not already converted to U.S. dollars by the carrier on the invoice summary.

The data were cleaned by deleting those shipments with a mix of 20s and 40s (and only a single tariff noted), and those which were repositionings or billed on another voyage and therefore no tariff was recorded. Those shipments traveling on multiple bills of lading, but in one container and with one tariff, were aggregated for weight data purposes and recorded as "consolidated cargo." The full data set Eastbound contains 50 2-digit SIC product categories of non-conference cargo and 60 product categories of conference cargo, while Westbound there are more non-conference categories at 57 with 53 conference product categories. The parameters of the data set appear in Exhibit 2. Although empty containers being repositioned were deleted from the data set, it is not possible to remove those containers being moved with very little cargo primarily for repositioning purposes and containing some revenue-contributing cargo which otherwise would not move; there is nothing on a bill of lading to indicate the extent of this practice and whether the particular container has been incrementally priced for this reason.

Exhibit 2: Statistics on Full Data Set

Voyage	Shipments	Containers	TEU	Mean* per TEU	Maximum* per TEU	Minimum* per TEU
1 (WB)	497	679	961	1.1783	5.5203	.1792
2 (WB)	505	681	971	1.1447	4.7638	.1792
3 (EB)	494	770	1103	.7741	4.2783	.0656
4 (EB)	357	636	861	.8587	9.5586	.0817
WB Total	1002	1360	1932	1.1616	5.5206	.1792
EB Total	851	1404	1962	.8100	9.5586	.0656
Total	1853	2764	3894	1.0000	9.5586	.0656

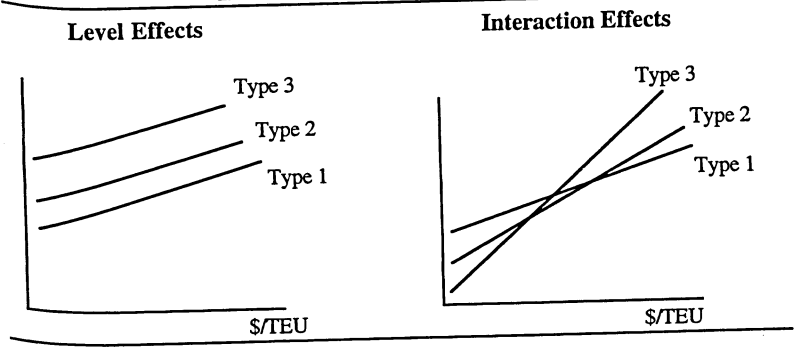
Note: * All means are reported as indexed to protect the confidentiality of the data. The difference between the means Eastbound and Westbound was tested and found to be significantly different (at p = .01).

For the purposes of analyzing the data, all alphabetic values were converted to numeric and where data were not ordinal, variations were coded via the use of dummy variables. The 2-digit SIC codes were aggregated into fewer classification categories as detailed in Appendix 1. These 14 commodity categories resulted in 13 dummy variables for the product shipped.

One objective of the study was to identify the factors influencing the price paid for liner services for standard containers on the North Atlantic trade route and to identify customer effects on price. There are two simple effects to consider, illustrated in Exhibit 3:

1) **level effects**, where the relationship between the co-variates and the price is the same for each customer type and the price is simply adjusted up or down after accounting for the various factors affecting price; and
2) **interaction effects**, where there is a different pricing formula for each customer type; that is, the contribution of weight, distance and so on varies by customer type.

Exhibit 3: Level and Interaction Effects



With level effects, the addition of the customer variable to the pricing formula results in prices remaining constant for one of the three customer types, with the other two each paying a constant amount more or less than the base formula. Referring to Exhibit 3, if there are three types of customers, Type 1 pays the base formula, while Type 2 and Type 3 pay an adjusted price. With interaction effects, pricing is not a simple adjustment to the base pricing formula but there is a different formula for each customer type, as illustrated by three unrelated formulae.

To account for these separately, the basic pricing factors without the inclusion of the customer type variables are examined. Ideally, once this has been accomplished, the customer variable is added to the pricing formula, the analysis is redone, and the customer effect tested by comparing the adjusted means. Because of the nature of the variables, and a large number of dummy variables, a compromise approach of examining the two formulae has been adopted.

The Model

The general model employed in this study is:

> Price per TEU for a dry van container = f (the commodity shipped, weight of the container per TEU in kilograms, the direction of the sailing on the particular trade route, conference or non-conference status of the shipment, the distance in nautical miles, container length, number of containers per shipment, and customer type)

This study does not include an estimate of the value of the goods or of the stowage factor as was the case with many earlier pricing studies. The commodity shipped (a 2-digit SIC code) provides a partial proxy for the value of the shipment as machinery and auto parts are clearly more valuable per TEU than agricultural products like navy beans or peat moss. The commodity and its weight relate to the stowage factor as commodities such as copper may weigh

out before they cube out. The study includes variables taken from the bill of lading and accompanying invoice summary.

On the North Atlantic it is often maintained by liner companies that ships will weigh before they cube out eastbound, because of the greater share of heavier boxes on that leg, but what is the impact of this on price? It may be argued two ways. Heavier boxes should pay more because fewer may be loaded, thereby providing fewer to spread costs over or, conversely, heavier boxes serve a useful and stabilizing ballast function if loaded at the bottom of the hold, thereby providing a compensable service for which a discount should be offered. Alternately, prices on the leg more heavily utilized may be higher than those on the underutilized leg in order to generate a more balanced traffic pattern.

Other variables, such as distance (nautical miles port-to-port), direction (easbound or westbound) and container length (20' or 40') have been included in previous studies and are examined here too, as is the role of conference or non-conference status of the shipment. Shipping a box on a longer ocean leg does have a cost component, as well as using space which might have yielded greater revenue from two shorter hauls. The vessel utilization on a leg (direction), and the confusion about how to explain its impact, have already been noted. Although the 40' differs from the 20' in port handling costs, it is not possible to know if this variable has a role in explaining ocean freight rate differences. The volume a shipper has should depress the rate paid per box as one would expect quantity discounts on the ocean leg for non-conference shipments. All data is actual not estimated.

A correlation analysis uncovered that the sailing direction and particular sailing dummy variables were highly correlated and so the direction variable was retained and the particular sailing variable dropped.

The methodology calls for the model to be analyzed, first with the full data set minus the customer type variables and then with them. For the analysis of customer effect, a random sample of 10% of each sailing's dry van shipments was taken. (As there would be very few non-dry van containers in the sample, the container type was also dropped from both the full data set and the sample.) This sample data set contains all of the information listed above, but with the addition of one variable—customer type—defined as **shipper** (the exporter who is sending the cargo to its destination and pays the freight bill), **consignee** (the importer who receives the cargo at its final destination and is responsible for paying the freight bill), and **forwarder** (a third party company, be it a freight forwarder or cargo consolidator, who acts on behalf of the shipper or consignee).

Classification was not so simple. Consignee buyers, of course, were obvious from the invoice summary and the bill of lading. But for other purchases not all customer types were readily classified. As each shipper or forwarder had to be identified from the name and address of the invoiced party, and qualified via overseas Canadian embassies and consulates or Canadian directories, only a 10% sample was selected for the second part of the analysis.

The sample data means were compared to the full data set means and the differences were not significant. (See Exhibit 4.) As with the full data set presented in Exhibit 2, the eastbound sample price was **significantly** less than the westbound sample price.

Exhibit 4: Comparison of 10% Sample to Full Data Set of Dry Vans Only

Variable	Full Data Mean*	Sample Mean*	T-stat	Significance
EB Dry Van	0.753	0.691	1.14	NS
WB Dry Van	1.122	1.085	0.699	NS

Note: All means are reported as indexed to protect the confidentiality of the data.
NS = not significant at p = .05.

General Findings About Liner Prices

In addition to the finding just noted that easbound prices are significantly less than westbound prices, preliminary analysis of the full data set supports the notion that shippers pay a premium for services involving specialized containers regardless of the direction. (See Exhibit 5.) (In addition, the weight differences directionally are also significant.)

Exhibit 5: General Comparisons on Full Data Set

Variable		Mean*	T-stat	Significance
Container Type EB	DV	0.733	-9.70	.000
	non-DV	1.382		
Container Type WB	DV WB	1.113	08.82	.000
	non-DV	1.625		
Weight	EB	15,627 kg	13.96	.000
	WB	11,372 kg		

Notes: * per TEU (USD prices indexed as in Exhibit 2.)

To specifically identify the role of the factors in liner pricing, the full data set without the customer type variable (or the container type variable) is evaluated based on the model. The regression results for the **full data set** (minus the variables having a probability greater than 0.05) are:

Predictor	Coef	Stdev	t-ratio	p
Constant	1655.1	216.6	7.64	0.000
Direction EB	-284.23	15.36	-18.51	0.000
Conference Shipment	177.93	15.07	11.81	0.000
Container Length 20'	195.33	17.83	10.96	0.000
Distance	-0.31	0.07	-4.28	0.000
Weight	-0.00989	0.002	-5.74	0.000
Commodity-Chemicals	112.63	26.10	4.32	0.000
Commodity-Wood	-119.83	40.26	-2.98	0.003
Commodity-Glass	-84.04	38.69	-2.17	0.030
Commodity-Transp. Equip.	-86.32	30.71	-2.81	0.005

with the following Analysis of Variance:

Source	DF	SS	MS	F	p
Regression	19	64892152	3415376	41.15	0.000
Error	1669	138512864	82992		
Total	1688	203405024			

s = 288.1 R-sq = 31.9% R-sq(adj) = 31.1%

Regression analysis on the full data set explains a significant proportion of the price for a container with the variables explaining 31.9% R^2 of the price variation. It confirms differential pricing between eastbound and westbound traffic with eastbound rates being substantially lower. It also corrorborates that conference prices are set at a premium over non-conference prices, although the magnitude is not as great as either the premium paid for westbound cargo or for cargo moving in a 20' dry van rather than a 40' dry van. This verifies to shippers that not only are there cube benefits of using a 40' over a 20' for lower density cargoes, but that there is also a price break associated with the choice. The impact of the weight of the container provides heavier commodities with a discount, perhaps reflecting their ballast contribution or the need to balance the trade or even the fact that many high value goods are less dense. Finally, the commodity class has a significant influence for some of the classifications. Surprisingly, higher value transportation equipment (including auto parts) gets a price break, while the very low value agriculture products category does not. Chemicals, including many hazardous products, do not get a price break; perhaps reflecting the risk to the carrier, but wood products and glass do. For all the discussion about commodity-based tariffs and price discrimination, the commodity results are, for some categories, surprising.

Is Customer Type a Determinant of Price?

Now to assess the impact of customer type, the smaller sample is examined. Remember the sample is statistically equivalent to the full data set. The regression results on the 10% sample (with customer type variables added) are:

Predictor	Coef	Stdev	t-ratio	p
Constant	832.9	610.0	1.37	0.174
Direction EB	-363.18	50.36	7.21	0.000
Conference Shipment	167.42	45.17	3.71	0.000
Container Length 20'	200.30	46.48	4.31	0.000
Commodity-Machinery	249.42	88.38	2.82	0.005
Shipper	-117.42	59.27	-1.98	0.049

Again the variables with a probability of greater than 0.05 have been deleted but are available from the authors on request. The Analysis of Variance table follows:

Source	DF	SS	MS	F	p
Regression	21	7571500	360548	6.29	0.000
Error	148	8488642	57356		
Total	169	16060142			

s = 239.5 R-sq = 47.1% R-sq(adj) = 39.6%

Although the premiums paid for westbound, conference and 20' shipments are relatively close to those noted with the full data set pricing formula, the regression analysis equation on the sample is different from the equation for the full data set. The constant term is approximately one-half the size of the constant term for the full data set. It would appear that these three factors—direction, length of container and conference status—their similar direction and magnitude coupled with the dramatic difference in the constant term exert a level effects influence. But this is the only evidence of level effects. Distance and weight are no longer an influence on the price. And the commodity influence calls different variables into play. Only the dummy variable for machinery shows a significant premium on the price paid. Therefore it is not likely that level effects model is entirely appropriate but that there is an interaction effects pricing equation for different customer types.

The equation including the customer type variables has a much greater predictive value with an R^2 of, a strong indicator of customer type influence..

Conclusions and Summary

This research, based on a unique and different type of data source—bills of lading and accompanying invoices, shows that there is already an influence on price by the type of customer being served. The customer variable has not been included in previous studies because they depended so heavily on the use of published tariffs, and the two approaches are incompatible. Whether the customer influence was present as an unexplained variation in previous studies is not known. It may also have gradually been incorporated through growing customer power over the past decade it may be only now being seen because of the serious restructuring taking place in the market.

As conferences are prohibited from establishing price levels for differing levels of service in Europe, one can only assume that these may have been incorporated into conference rate negotiations with shipper organizations over time for commodities where a few large shippers dominate the trade. It is likely that across-the-board adjustments to account for customer type (level effects) do not take place but that the pricing process is an interaction effects one.

As pointed out by Bennathan and Waters (1969) there is no substitute for qualitative knowledge to accompany modeling such as undertaken here. Some of the prices seen may well be due to long-term contracts providing an effective rebate or the carrier incurring repositioning losses to place an empty container in a needed location for a regular customer with significant but seasonal volume.

Customer differences provide an alternate basis for setting prices. Brooks (1993) identified that significant customer differences in requirements exist. In her study, large shippers in North America and Europe were similar in their needs but the pattern of requirements between North America and Europe is somewhat different for freight forwarders. Freight forwarders in Europe place greater value on timely pick-up than do their North American counterparts. North American consignees place greater value on transit time and on-time delivery than do their European counterparts. Neither consignees in North America or those in Europe place great importance on the price of the service. These service patterns may provide scope for further price differentiation, providing pricing opportunities if the complexities of such demands can be

translated into service levels where price differentiation can be effectively implemented. Obviously this will require conference operators to look seriously at their options as the Competition Directorate of European Union has ruled that the TAA may manage capacity or rates but not both.

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Appendix 1: Standard Industrial Classification Aggregation

Codes 1-5	Animal and vegetable products including live animals
Codes 16-24	Prepared foodstuffs, beverages including liquor, and tobacco products
Codes 25-27	Salt, ores and mineral fuels
Codes 28-38	Products of the chemical industry, including fertilizers and pharmaceuticals
Codes 39-40	Plastic and rubber articles
Codes 41-46	Fur and leather products, wood, including lumber, cork and straw, including wicker
Codes 47-49	Pulp and paper products, including published materials
Codes 50-67	Textiles, apparel, footwear
Codes 68-70	Articles of stone, cement, ceramic or glass
Codes 72-83	Base metals and articles of base metals
Codes 84-85	Machinery
Codes 86-89	Transport equipment and parts
Codes 90-96	Instruments and miscellaneous manufactured articles, including household goods
Code 98	Consolidated cargo

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