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Résumé de l'article

Cette étude analyse les facteurs qui influencent la taille des ports situés en aval de Québec, sur la côte sud de l'estuaire du Saint-Laurent. Elle utilise les résultats des recherches antérieures sur la géographie portuaire et mesure les corrélations entre six facteurs et la taille portuaire. L'analyse de régression multiple propose un modèle qui rend compte de plus de 90% de la variance de la taille dans le système portuaire.

AN EXPLANATION OF PORT ACTIVITY ON THE SOUTH SHORE OF THE LOWER ST. LAWRENCE RIVER

by

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In 1966 there were twenty three active ports on the south shore of the lower St. Lawrence River between Québec City and Gaspé. This study provides an analysis of the factors that influence size variations in this port system. Earlier studies [1] in port geography have indicated that six factors may be considered : the hinterland, competition from other transport systems, facilities, economies of vessel size, competition from other ports, and the foreland. Unfortunately the relationships examined in these earlier works were not measured precisely, indeed there has been little discussion of possible surrogates.

This analysis begins with a review of a large number of possible criteria that may be used to represent each of the factors. Data collection was facilitated by 1966 being the year when a number of important sources were published : partial census [2], Scott's Industrial Directory of Quebec [3], the St. Lawrence River Pilot [4] ; furthermore the smallness of many of the ports in the region enabled other types of data to be collected in the field without too much difficulty. The selection of this particular year to test relationships does not appear to have introduced bias in the analysis, as 1966 appears to have been a fairly representative year of shipping.

The study then goes on to include the surrogates in a multiple regression analysis. The regression analysis is intended to provide a general explanatory model of port activity in the study area. Although the question of choosing the best criterion of port status is still unresolved [5], « wharfage » is used here. Wharfage represents the revenue collected by the Federal Government at Canadian ports, and has been shown to be an appropriate measure of port status in Canada. [6]

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1 For example : WEIGEND, G. (1958) Some Elements in the Study of Port Geography. *Geographical Review*, pp. 185-200.

2 *Census of Canada*, 1966. Ottawa.

3 *Scott's Industrial Directory of Quebec*, Oakville, 1966.

4 *The St. Lawrence Pilot*, Canadian Hydrographic Survey, Ottawa, 1966.

5 RIMMER, P. J. (1966) The Problems of Comparing and Classifying Seaports. *The Professional Geographer*, pp. 83-91.

6 SLACK, B. (1972) *A Geographical Analysis of the System of Ports on the South Shore of the Lower St. Lawrence River*, Unpublished Ph.D. dissertation, McGill University, p. 40.

Table 1

Ports Active in the Study Area in 1966

	Port	Wharfage ($)		Port	Wharfage ($)
1.	Berthier	1,058	13.	Les Méchins	2,132
2.	L'Islet	1,572	14.	Cap-Chat	3,779
3.	Saint-Jean-Port-Joli	4,658	15.	Sainte-Anne-des-Monts	2,785
4.	Rivière-Ouelle	1,245	16.	Sainte-Marthe	219
5.	Kamouraska	1,578	17.	Marsoui	1,171
6.	N.-D.-du-Portage	226	18.	Mont-Louis	10,649
7.	Rivière-du-Loup	12,700	19.	Madeleine	826
8.	Trois-Pistoles	4,935	20.	Grande-Vallée	2,786
9.	Rimouski	97,087	21.	Cloridorme	788
10.	Sainte-Flavie	204	22.	Saint-Maurice	116
11.	Baie-des-Sables	802	23.	Rivière-au-Renard	2,519
12.	Matane	7,099			

(Numbers identify ports on the maps, figures 1 and 3)

Source : Sessional Papers, House of Commons.

A. SELECTION OF SURROGATES AND MEASUREMENT OF RELATIONSHIPS

Thirty seven variables were collected as possible surrogates. Correlation of the variables and wharfage (X_1) provides a quantitative measure of the strength of the associations and allows the most significant criteria to be identified. Spearman's Rho rather than Pearson's product-moment coefficient of correlation is employed because all the data are not normally distributed. Most of the variables possess distributions that are positively skewed and several defied normalisation despite several transformation routines. However, as Cole and King have commented : « It is the general impression of the authors from work they have done in which the Spearman's rank correlation test and product-moment test have been applied to the same data that the results do not usually differ appreciably. » [7]

1. *The Hinterland Variables*

a) *The Hypothesis*

Because the hinterland is the trade area of a port, it may be looked upon as the generator of traffic, whether the cargoes shipped through the port are produced there (exports), or are consumed within that region (imports). Strong positive relationships between hinterland size and port activity are hypothesised therefore.

b) *Selection of hinterland measures*

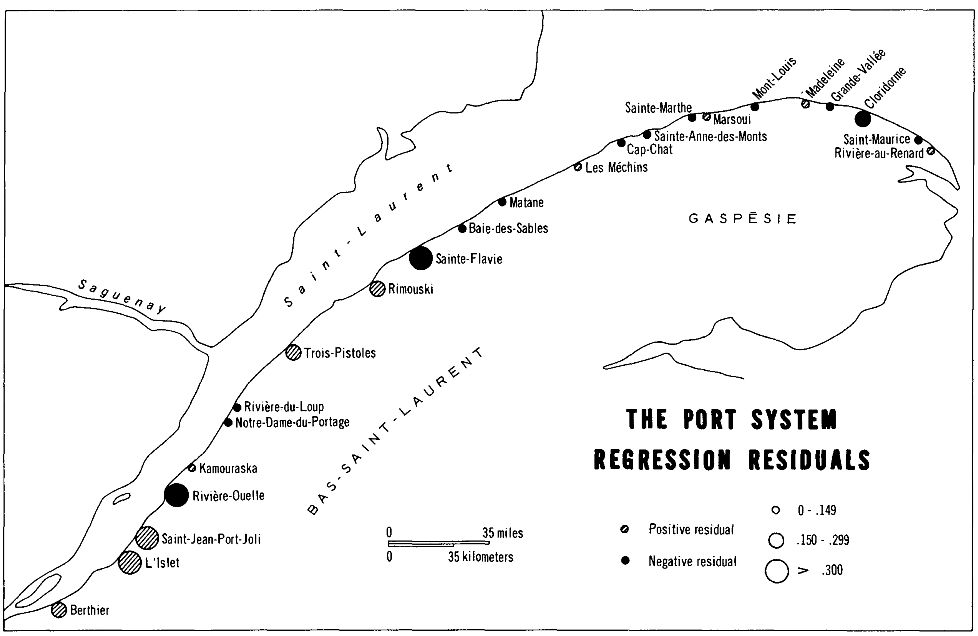
Fourteen variables representing aspects of hinterlands of the ports were selected to test the hypothesis. Two of them give a crude measure of

[7] COLE, J. P. and C. A. M. KING (1968) *Quantitative Geography,* London, p. 152.

the extent of the total area served by each port. X_7 represents the size of the hinterland. It was determined by marking the boundaries of each port's trade area as obtained by field work on topographic map sheets of the 1:250,000 series. A planimeter was used to calculate the area in square miles. X_6 represents the maximum range of each port's hinterland. It is based upon the distance by road to the furthest point of each trade area. Another variable representing the competitive hinterlands of the ports is X_8. This indicates the population of the maximum umland, and was obtained from the 1966 Census by summing the population totals of the parishes and municipalities in each port's hinterland.

In order to discover the extent to which size and quality of the local hinterland [8] (figure 1) might influence the ultimate size of ports (i.e. did Rimouski develop as the largest port because its local trade was more extensive in the first place ?), variables measuring the nature of the local umlands are included. (Note that local hinterlands represent the only areas served by eighteen of the twenty-three ports active in the study area). An advantage of dealing with local hinterlands is that their boundaries are discrete, so that no problems exist concerning the assignment of individuals. Because of overlapping competitive hinterlands, the same individual could be counted several times if it were located in the competitive zone of several ports.

Figure 1



8 Local hinterland may be defined as the area closest to a particular port.

Although in this group of measures of the primary hinterlands both area and population parameters are included again as X_4 and X_5 respectively, most of the variables deal with aspects of the regional economy. The same procedure as described in the case of X_8 was followed to provide measures of farming, but great difficulty was encountered in the case of manufacturing data. The range of data published by Statistics Canada on the industrial structure of the study area at the scale required is limited. The disclosure laws effectively prohibit publication of the type and number of industries, number of employees, and value added at any level lower than the county unit, far too large for the needs of this study. Thus in the case of measures of industry in the region, the less reliable and complete Scott's Industrial Directory of Quebec was used.

X_3 population of port town. (Census of Canada 1966).

X_4 area of local hinterland (Calculated from questionnaires and field survey).

X_5 population of the local hinterland 1966. (Census of Canada 1966).

X_9 number of manufacturing establishments 1966. (Scott's Industrial Directory of Quebec).

X_{10} number of manufacturing employees 1966. (Scott's Industrial Directory of Quebec).

X_{11} farm population 1966. (Census of Agriculture 1966).

X_{12} area of woodland 1966. (Census of Agriculture 1966).

X_{13} area of farms 1966. (Census of Agriculture 1966).

X_{14} % of farmland wooded 1966. (Census of Agriculture 1966).

X_{15} tonnage of commodities from local hinterland (analysis of primary Statistics Canada shipping data).

A final variable, X_2, measures the length of the river on which the port town developed. It has been included as a surrogate for the extent of natural access to the interior. Most of the port towns are located where a tributary joins the St. Lawrence, and a suggested advantage is access to the interior.

c) *Results*

Table 2 presents the results of the correlation tests. Several interesting associations are revealed. Very weak correlations between port activity and measures of the economy of hinterlands are indicated. This finding contrasts with the relationships suggested by other researchers concerning the role of the economy of the hinterland. While lack of precision in the measures of the variables themselves or errors in data gathering may account in part for the weak relationships, more basic explanations need to be uncovered.

A surprising result is the relatively high correlation between size of port town (X_3) and port activity. This strong relationship suggests that a mutual interaction exists. Not only does the port town generate trade, but it may be observed that the port itself is important to the economy of coastal set-

Table 2

Hinterland Variables : Coefficients of Correlation (Spearman)

		wharfage X_1
X_2	length or river	.53
X_3	pop. port city	.76
X_4	area of local hinterland	.61
X_5	pop. local hinterland	.44
X_6	maximum range	.56
X_7	area maximum hinterland	.64
X_8	pop. maximum hinterland	.56
X_9	number of manufacturing estabs.	.33
X_{10}	number of manufacturing employees	.28
X_{11}	farm population	.47
X_{12}	area of woodland	.42
X_{13}	area of farms	.36
X_{14}	% of farmland wooded	.30
X_{15}	tonnage of cargoes from local hinterland	.74

$n = 23$

coefficients $>$ .53 are significant at the 99.5% confidence level.

tlements. Local employment is generated directly and indirectly by ports. The direct effect of the port on local employment is expressed by labour demands in the harbour (quite small in the minor ports in the study area), in the ancillary services created by shipping (e.g. chandlers), and in the storage, handling and processing of commodities shipped (e.g. petroleum depots). Indirectly, the injection of large quantities of capital for harbour construction and repair stimulates a section of the economy by supporting a local construction industry.

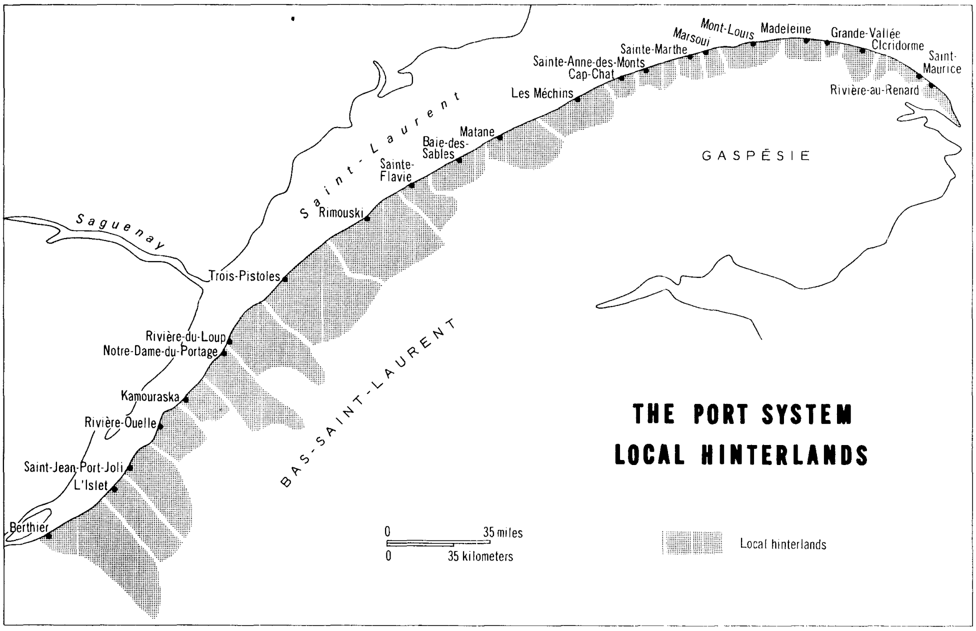
It is evident that of all the variables, those representing the maximum hinterland areas are most highly associated with port size. Both area and population of the total hinterland are related significantly to port activity. However, the success of X_{15}, indicates that local trade is an important aspect of the function of ports.

2. *Land Transport*

a) *The hypothesis*

Only rarely are production or consumption points at dockside. Most commodities produced or consumed in the hinterland have to be transported by land transport systems to the port. Hence it is hypothesised that significant positive relationships will be found between port size and the extent of road and rail networks in the hinterland.

Figure 2



b) *Results*

This is a very difficult hypothesis to test. In most areas land transport systems compete with water transport for the trade of hinterland regions. Thus on the one hand land transport may be seen as a positive factor affecting the size of ports, on the other either road or rail systems may divert trade from ports.

This conflict is reflected in the very poor correlations derived when miles of road in the hinterlands of each of the ports are compared with port size. X_{16}, road mileage, produces a correlation coefficient rho of .44, and X_{17}, rail mileage, produces a coefficient rho of .11. Only the correlation between X_{16} and wharfage is significant at the 95% confidence level.

c) *Competition from land transport*

Comparative freight rates are usually taken as measures of the degree of competition between different transport systems. Most economic geography texts base their comparisons of water, road, and rail transport in terms of cost/distance measures in the manner portrayed in figure 2. This represents a gross over-simplification. In the study area competition between different transport systems as expressed by freight rate differentials is very complex. Although the *Bureau d'Aménagement de l'Est du Québec* (B.A.E.Q.) managed to unravel many of the complexities of the freight rate structure, their findings could not be presented in a way that would permit derivation of quantifiable measures of association with port size.

Several different sets of freight rates may be applied to commodities shipped by land transport. [9] The first group depend upon the type of product. Differential rates apply to different classes of goods — hence these rates are called class tariffs. The criteria for establishing the class of a product are factors such as weight in relation to volume, fragility , and value. Furthermore large shipments of the same type of product will result in lower rates, because the larger shipment will be assigned a lower class grouping. Thus, butter falls into class 100 for shipments of less than a car load of 20,000 lbs, whereas if shipped in lots greater than car load, butter is rated as a class 55 product. These classes represent a proportionate sliding scale, so that rates are set for class 100 only. To find freight rates on butter shipped in quantities greater than car load, it is necessary only to calculate 55% of the class 100 distance rate.

A second group of freight rates, called special rates, apply where large quantities are shipped between specific points. The rates are not determined in any particular systematic fashion. Many of the goods transported to and from the study area take advantage of these lower charges e.g. building materials, timber, fish, meat, butter and cheeses. These special tariffs completely invert geographical distance. It may be much cheaper to transport a product between Montréal and Rimouski than Montréal and Rivière-du-Loup, if the former shipment was based on special rates, while the latter was rated by class tariffs.

Both of these rates are employed by rail and trucking systems. However, the railroads also take advantage of being permitted to charge convened rates. These are fixed rates agreed upon by the shipped and the railway for any shipment of a particular product between specific points. The oil companies have obtained such rates for the distribution of petroleum from Rimouski.

Only class tariffs are available in published form, the other cases being for the most part impossible to obtain. It may be noted, however, that public carriers are subject to rates established at certain base points only :

> « le tarif 200G qui régit le déplacement des commodités de ou vers le territoire-pilote prévoit cinq localités d'entête : Rivière-du-Loup, Rimouski, Mont-Joli, Matane, et Amqui. Cela signifie que tout déplacement de produits effectué entre deux points du territoire non inclus dans ces localités se calcule au millage » [10].

Geographic distance thus reasserts itself.

The complex patterns produced by the application of these different freight rates is complicated further by the effect of government subsidies. The study area is part of the region benefitting from the Maritimes Freight

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[9] This section draws freely on the findings of B.A.E.Q., *Les Transports,* Mont Joli, 1966, pp. 79-118.

[10] *Ibid.,* p. 102.

Rate Act (M.F.R.A.). The provisions of this act allow for subventions on the transport of goods which amounted to a 30% reduction of freight rates in 1966. These reductions do not apply to trucking however, and are applicable only to goods being shipped out of the region. Consequently, any product being shipped by rail from the study area to other parts of Canada obtain a 30% reduction in rates for that portion of the trip lying within the area benefitting from M.F.R.A. (everywhere east of Lévis). These reductions are not available on return trips.

d) *Conclusion*

The difficulty of measuring freight rates of the land transport systems meant that comparisons of port activity and competition from land transport were not possible. While omission of quantifiable relationships between size of ports and this factor represents a loss of accuracy, the implications are referred to in a later section.

3. *Facilities*

a) *The Hypothesis*

The term facilities is employed to cover all features, equipment, installations, and labour in the harbour itself. The facilities of a port permit the transfer of goods from ships to land transport systems, and vice versa. Facilities may be seen therefore to influence the amount of trade a port may handle. A strong positive relationship may be hypothesised between measures of port facilities and trade.

b) *Selection of the variables*

The choice of suitable measures of port facilities is influenced by the nature of the facilities themselves and by the availability of data. Thus studies of facilities in Great Britain might consider number of cranes possessed by the port, whereas in Canada such a variable would be meaningless as ships' gear is used for the most part in handling general cargo. Because the ports in the study area are small, they possess few of the facilities found at larger ports such as Montréal. Few of the ports possess storage sheds, and Rimouski is the only one whose berths are served by rail. Consequently, to make correlations as meaningful as possible only features common to all the ports have been selected.

Length of wharves (X_{19}) is an obvious measure of port facilities. Such a variable influences the number of berths available and the ability of ports to accomodate vessels. This measure was obtained from the *St. Lawrence Pilot* of 1966.

Despite the apparent attractiveness of this variable, is possesses one limitation. It is possible for ports to possess long wharves not for the purpose of providing extensive berthing space, but to extend out to deeper water so as to accommodate vessels that would otherwise be excluded from the port.

Depth of water in the harbour, X_{16}, may be inferred to have a bearing on trade. Since ports with shallow water alongside berths are able to accommodate shallow draught vessels only, this limitation should be expressed in trade activity. Several problems are presented by this measure however. All the ports are tidal, and the tidal range is extremely variable, being much greater in the upstream portions. Also because wharves generally extend out into deeper water, there are great differences in depths alongside different berths. In an attempt to standardise this measure, the data, which were again obtained from the *St. Lawrence Pilot* of 1966, represent the maximum depth available at wharfside at mean low water.

A desirable variable would be a measure of shelter. One of the basic reasons for a port's existence is to provide ships with shelter from storms, tides, and currents. It has been shown that natural shelter was a prime factor in the selection of the original port site. As the need for more space and greater depths asserted itself, artificial shelter was provided. Unfortunately it has been impossible to obtain any quantifiable measure of shelter, whether natural or artificial. Discussions with engineers in the Department of Public Works indicated that the question was too complex and that there are too many variables to be considered. There is no measure of shelter that could be applied to all the ports in the study area.

Measures of the quality of port facilities were sought. Comparisons based upon length of wharves may not be meaningful if there is a wide variation in the state of repair of the docks. The files of the regional office of the Department of Public Works were made available and from these records four variables were obtained. X_{20} represents the total amount of money spent by D.P.W. since records began. This figure includes both capital and maintenance costs, as well as expenses incurred in dredging operations. X_{21} represents the amount spent in the period 1946-1966, since large sums may have been spent a long time ago, but lack of recent expenditures could result in decrepit facilities today. X_{22} indicates the percentage increase in expenditures between 1946-1966. These three variables are not completely satisfactory indicators of quality of facilities, since amounts spent by D.P.W. are influenced by the extensiveness of facilities there. Thus a relative measure, X_{23}, was obtained. This variable represents the amounts spent between 1946-1966 per unit length of wharf, and was obtained by dividing X_{21} by X_{19}. The presumption is that the more spent per foot of wharf the higher the quality of the facilities.

c) *Results*

Two of the variables do not perform well. No relationship between X_{22} and port activity is indicated. This poor correlation may be explained by imperfections in the data. Several of the smallest ports registered very large percentage increases over the 20 year period because amounts invested prior to 1946 were so small.

Table 3

Facilities Variables : Coefficients of Correlation (Spearman)

		wharfage X_1	
X_{18}	depth of water	.43	
X_{19}	length of wharves	.76	
X_{20}	total expenditures D.P.W.	.79	
X_{21}	increase D.P.W. expenditures 1946-1966	.75	
X_{22}	% increase D.P.W. expenditures 1946-1966	−.17	
X_{23}	amount spent per foot of wharf 1946-1966	.61	n = 23

coefficients > .53 are significant at the 99.5% confidence level.

The weak performances of depth of water in explaining port activity is more surprising. Part of the reason is the physical structure of the estuary of the St. Lawrence. Ports located closer to the Gulf of St. Lawrence have access to deeper water, regardless of their size. A further factor is that the relationship may not be a simple linear one. Instead a step function may be hypothesised where certain critical depth values exist and a relatively small increment may raise substantially port activity. [11]

4. *Competition from other ports*

a) *Hypothesis*

While significant relationships between the intrinsic qualities of facilities and port size have been revealed, it is felt that an element in the performance of a port must be its competitive position compared with other ports. Ports compete with each other for the waterborne trade of a region, and their relative success may be measured by their trade totals. It is hypothesised, therefore, that port activity is positively related to the strength of a port's competitive position.

Ideally the competitive position of ports should be reflected in variations in costs of transferring products to and from regional hinterland markets and foreland areas. Unfortunately actual cost data are unobtainable. Here, distance is utilised as a substitute measure, and it is assumed that distance of a port from its competitors is a factor in trade. It would appear to be an appropriate measure of a port's competitive position because ports compete spatially, and transport costs are largely based upon distance measures. [12]

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11 SLACK, B., *opus cit.*, p. 138.

12 This is justified in light of quotation on page 141.

b) *Selection of the variables*

Nine variables were derived from distance measures to test the hypothesis. Actual road distances between wharves were obtained (using the odometer of a car), instead of relying on published distances between port settlements. Several harbours are some distance from the centre of town, e.g. Rivière-du-Loup.

X_{24} represents the distance to the nearest port. It is hypothesised that proximity to a competing port will limit port activity.

Variables X_{25} — X_{29} inclusive indicate distances to the nearest larger port. Each variable represents a different attribute of port size. It is implied here that the competitive position of a port will be seriously reduced whenever it is close to a larger port. X_{32} could be interpreted in a similar way. This variable represents the distance to the nearest port of higher order in the functional hierarchy.

X_{30} and X_{31} are based upon port facilities, depth of water and extent of wharves respectively. It is suggested in the case of these variables that trade will accrue to ports possessing superior facilities, and thus proximity to a port with better facilities will hinder the development of trade.

Table 4

Competition Variables : Coefficients of Correlation (Spearman)

	wharfage X_1	
X_{24} distance nearest port	.17	
X_{25} distance nearest port handling more commodities	.73	
X_{26} distance nearest port generating higher wharfage totals	.78	
X_{27} distance nearest port handling greater vessel tonnage	.69	
X_{28} distance nearest port handling more vessels	.68	
X_{29} distance nearest port handling greater tonnage of cargo	.72	
X_{30} distance nearest port with deeper water	.31	
X_{31} distance nearest port with longer wharves	.32	
X_{32} distance nearest port of higher functional order	.61	n = 23

coefficients $>$ .53 are significant at the 99.5% confidence level.

c) *Results*

Examination of the correlation coefficients rho indicates that of the various sets of variables, those measuring distances to ports of greater size perform best. Distance from the nearest port (X_{24}) reveals little relationship with port activity. The nearest port under these conditions could in fact be a smaller, less efficient port, and this vagueness is reflected in the poor correlation. Measures of port facilities too perform poorly. Proximity to a port with superior facilities was not found to be significant, therefore.

Of the variables measuring distance from a larger port, X_{26} produces the highest simple correlation with wharfage. The hypothesis that the probabilities of a port attaining great size are seriously reduced when that port is close to a large port is substantiated.

5. *Vessels*

a) *Hypothesis*

Vessel size and numbers may be regarded as attributes of port size, indicative of, rather than causally related to, port activity. However, as carriers of the waterborne trade of ports, vessels may be seen as factors in port growth. Thus although vessel frequencies and size may be looked upon as being *products* of port activity (because the availability of cargo attracts vessels), it must be recognised that their very presence generates trade and enhances the competitive position of the port. Economies of vessel size [13] are considerable and have obvious repercussions on the competitiveness of those ports that can generate sufficient trade to attract the largest vessels, in the first place, and which possess the physical facilities to accommodate them. Thus great advantages are conferred on those ports that can attract a large number of vessels, and, in particular, vessels of a large net registered tonnage. The hypothesis to be tested in this section is that strong positive relationships exist between traffic and port activity.

b) *Selection of the variables*

Because details of the movement of every ship in each of the ports in the region were investigated at Statistics Canada, not only was it possible to produce such gross measures as total tonnage of vessels (X_{33}), number of ships (X_{34}), and the derivative data on mean vessel size (X_{36}), but two other variables based on data not published anywhere. Size of the largest vessel handled by the ports in 1966 is presented as X_{35}, and actual tonnage of the largest cargo shipment is included as X_{37}. Both of these variables have been included because of the importance of economies of scale implied in the hypothesis.

[13] HEAVER, T.D., (1968), *Economies of Vessel Size,* Ottawa.

Table 5

Vessel Variables : Coefficients of Correlation (Spearman)

		wharfage X_1	
X_{33}	total n.r.t. or vessels 1966	.88	
X_{34}	number of vessels 1966	.82	
X_{35}	size of largest ship handled 1966	.70	
X_{36}	mean vessels size (X_{33}/X_{34})	.41	
X_{37}	tonnage of largest cargo shipment	.65	n = 23
	coefficients > .53 are significant at the 99.5% confidence level.		

c) *Results*

Some very high correlation coefficients are indicated in Table 5. Only the variable measuring mean vessel size is not significantly related to port activity. This poor result may be accounted for by imperfections in the measure itself. Mean ship sized at many of the larger ports (Which attract the bigger vessels) are deflated by arrivals of large numbers of *goélettes* — the small 100 n.r.t. ships used in the pulpwood trade.

Of all the variables, net registered tonnnage is most highly associated with port activity. The hypothesis appears to be substantiated, therefore. Larger ports attract great numbers of ships of a large net registered tonnage.

6. *Forelands*

a) *Hypothesis*

The foreland of a port is its overseas trade area. It may be noted that the ports on the south shore of the lower St. Lawrence River are small and possess relatively simple foreland relationships. By the nature of their trade most of the ports are linked with comparatively few other regions. The pulpwood is shipped to either Port-Alfred, Québec City, or Trois-Rivières, and this represents the limit of the trade of several of the ports. Trade with other ports across the river on the north shore of the St. Lawrence is quite extensive, with large quantities of local agricultural produce and timber being shipped. In addition, large tonnages of general cargo and petroleum are shipped there from Rimouski. Trade with Montréal is characterised by imports of general cargo at ports east of Matane, and petroleum imports at Rimouski. Links between ports in the region and areas beyond the St. Lawrence are few. The major item in this trade is petroleum imported from refineries in the Maritimes and the Dutch West Indies. However, Rimouski exports timber to the United Kingdom, and explosives to Newfoundland and South America.

It is hypothesised, therefore, that a strong positive association exists between foreland size, as measured by the number of different ports traded with, and wharfage.

b) *Results*

The number of different ports trading with each of the ports in the study area was obtained from primary Statistics Canada data. This variable (X_{38}) when correlated with wharfage (X_1), produces a statistically significant coefficient rho of .80. This suggests that the hypothesis cannot be rejected, that the foreland component is related significantly to port activity. However, this high correlation does not suggest that there is causal relationship between the foreland component as measured here, and port trade. The association is seen more as an indication of a mutual interaction between the two variables. Thus the number of ports traded with may be a corollary of port size rather than a cause.

B. MULTIVARIATE ANALYSIS

The analysis so far has been concerned with measuring hypothesised associations between port size and various separate components. A further product has been the identification of particular measures of the components which generate the most meaningful correlations. A general conclusion it that although there are variations in the strength of the different correlations, each of the elements is related significantly to port activity.

It should be evident that although individual elements correlate highly with port size, the performance of a port must be seen as the product of several, if not all, of these components.

> « The majority of spatial distribution in which geographers are interested are typically so complex in their structure and relationships that they cannot be explained satisfactorily in terms of one variable ». [14]

Variations in port activity can only be explained through use of multivariate techniques. A type that has been used very frequently in geography is multiple regression analysis.

Multiple regression differs in a number of ways from the correlation analysis presented earlier. It assumes that there is some functional relationship between dependent and independent variables :

$$Y = f(X_1) + f(X_2) + \dots + f(X_n) + \Sigma \qquad (1)$$

Correlation implies no such functional dependence, although it is very commonly used to search for possible relationships, and, as illustrated, is an effective technique for 'sorting out' associations. Because in most regression

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[14] KING, L.J., (1969) *Statistical Analysis in Geography.* Englewood Cliffs, p. 135.

analyses the functional relationships are assumed to be linear, the model becomes :

$$Y = a + b_1X_1 + b_2X_2 + \ldots b_nX_n \quad (2)$$

Both dependent and independent variables are required to be normally distributed and measured on interval or ratio scales.

These requirements of regression analysis necessitate careful selection of variables. The selection procedure was based on the results of the correlation analysis. However, because the data used in the correlations rho were not distributed normally, transformations were necessary. Two criteria were employed : for each of the elements held to be related functionally to port activity, the variable or variables most highly correlated with wharfage totals were chosen ; these variables were then transformed, but if this was unsuccessful the next most highly correlated variable was included. It will be remembered that most of the variables possessed positively skewed distrbutions, and thus simple log transformations were found to be sufficient to achieve normalcy as tested by scatter diagrams.

On this basis the following variables were obtained :

Y = log wharfage	Wharfage is a good measure of port size and is here used as the dependent variable.
X_1 = log vessel tonnage	This was the most highly correlated of the vessel component variables.
X_2 = log population of maximum hinterland	Although area of maximum hinterland correlated more highly, its distribution could not be normalised despite several different transformation procedures.
X_3 = log population of port town	The highest single correlation between port activity and the hinterland element was produced by this variable.
X_4 = log quality of facilities ($ spent 1946-66 / length of wharves)	While not the highest simple correlation, was held to be the best measure of quality of facilities.
X_5 = log length of wharves	Included to provide a measure of the extent of facilities.
X_6 = log distance nearest larger port	This was the most highly correlated of the variables measuring competition from ports.

It must be noted that the original variables have now been renumbered : thus X_8, population of the maximum hinterland, is the rank order equivalent of the normally distributed transformed variable X_2.

Using the transformed data, Pearson's product-moment coefficients of correlation were obtained and compared with the performance of the rank order coefficients in Table 6.

Table 6

Comparison of* r *and* rho *Coefficients of Correlation

		X_1	X_2	X_3	X_4	X_5	X_6	
wharfage	rho	.88	.56	.76	.61	.76	.78	n = 23
	r	.87	.56	.77	.65	.76	.83	

coefficients > .53 are significant at the 99.5% confidence level.

The high degree of agreement between the two sets of correlation coefficients substantiates the statement of Cole and King[15] made earlier, and reinforces the significance of the results obtained from Spearman correlation analysis.

A stepwise procedure was employed in the multiple regression analysis. This is a technique of adding one independent variable at a time and generating a series of intermediate regression equations. It is an interative procedure that has been used frequently in recent geographical situdies,[16] and because of its computational complexity requires use of a computer. Most stepwise regression computer programmes add variables generating the highest partial correlation coefficients. However, the algorithm followed in this study employs analysis of variance.[17]

The computer is programmed to continue in the stepwise regression until all variables are included. It then proceeds to calculate the residuals from the regression, using the final regression equation. Because there is no guarantee that the results would be statistically significant, the computer was programmed to terminate the stepwise iteration when the F. test fell to 1.0. Below this level any variable introduced would not account for any significant variance reduction. Thus the residuals were determined only from variables statistically significant in the regression equation.

The results of the stepwise multiple regression analysis are contained in Table 7. In step one, the vessel size variable is introduced. This variable alone accounts for 76% of total variation in port activity. Its inclusion reduces to 2.78 the residual sums of squares.

The second variable entered is the measure of competition from other ports. The regression equation incorporating variables X_1 and X_6 now

[15] *Opus cit.,* p. 162.

[16] OLSSON, G., (1965) Distance and Human Interaction. *Geografiska Annaler,* pp. 3-43.

[17] YATES, T.E., ed., (1967) *Stepwise Multiple Linear Regression.* Portland, Oregon State University.

accounts for 82% of total variation in port size. These two variables together now reduce the unexplained variance about Y to 1.66.

The remaining two variables added represent measures of the extent and quality of facilities. By the time the stepwise iteration is completed, their inclusion raises the coefficient of determination to .901.

The complete multiple regression equation becomes :

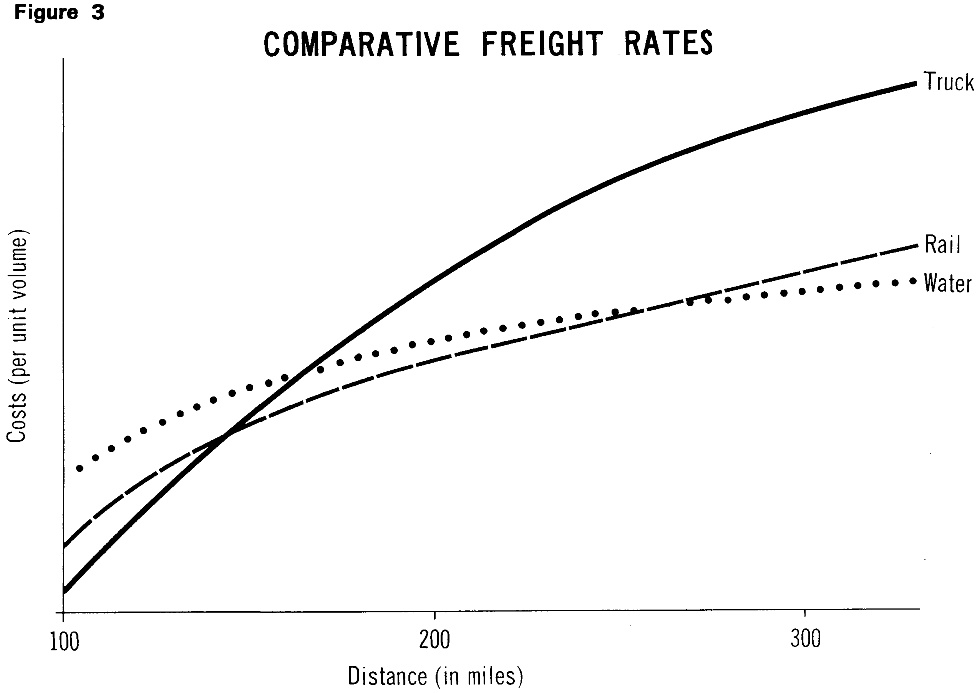
$$Y = -1.44 + .277X_1 + .326X_4 + .61X_5 + .627X_6 \qquad (3)$$

As shown in Table 7 this is a very powerful explanatory model, accounting for just over 90% of variation in port activity in the study area. As the F tests of variance and the t tests of the beta coefficients indicate, the model is significant at the 97.5% level.

It is noteworthy that neither of the hinterland variables were entered. This suggests that the hinterland element (as measured by these two variables) is not a factor in the statistical explanation of port activity on the south Shore of the lower St. Lawrence River. This appears to contradict the importance usually given the hinterland component by port geographers. This regression analysis suggests that vessel size, quality and extent of facilities, and competition from other ports are the major elements explaining port activity in the study area.

The next step is to produce predicted wharfage totals from the regression model. These predicted values are compared with the log transformed wharfage data and the residuals from the regression listed in Table 8. The residuals, as deviations from predicted values, are mapped in figure 3.

Figure 3



Source : Morrill

Table 7

Stepwise Multiple Regression Analysis

INITIAL TABLEAU

variable	*mean*	*standard deviation*
Y	3.256	.663
X_1	3.956	.718
X_2	3.817	.634
X_3	3.298	.436
X_4	2.652	.446
X_5	3.041	.276
X_6	1.377	.385

n = 23

SYY = 9.683

STEPWISE PHASE

Step	*Variable Entering*	*SSE*	*R^2*	*Constant*	*F Level*	*Regression Coefficient*		*T Value*
1	X_1	2.278	.7638	.0605	67.9058*	X_1	.8078	8.240*
2	X_6	1.656	.8289	.2037	7.6185*	X_1	.5263	3.956*
						X_6	.6847	2.760+
3	X_5	1.266	.8693	−1.116	5.8660*	X_1	.3900	2.956*
						X_5	.6541	2.421+
						X_6	.6103	2.717+
4	X_4	.959	.9009	−1.4416	5.7523*	X_1	.2770	2.180+
						X_4	.3236	2.398+
						X_5	.6180	2.553+
						X_6	.6276	3.122*

FINAL TABLEAU

SSE .959 R^2 .9009 Constant −1.4416

	X_1	X_4	X_5	X_5
regression coefficient	.2770	.3236	.6180	.6276
standard error of coefficient	.1270	.1349	.2420	.2010

* significant at the 99.5% confidence level

\+ significant at the 97.5% confidence level

Considering that the regression model accounts for 90% of total variation in port size, it is not surprising that the residuals, as expressions of unexplained variation or error term, are small, the largest being 16%. Under these circumstances it is to be expected that strong patterns of positive or negative residuals will not be evident.

> « If the residuals do show a strong pattern, then it may be that the explanatory model being considered is not a very powerful one since the variables in it are not accounting fully for spatial variations in the independent variable » [18]

Only four values are in excess of .3000 from the predicted wharfage total. There is no clear pattern of positive and negative residuals. This suggests that the model is sound with no under or over prediction in any one part of the region.

There appears to be no influence of port size or function on the extent and nature of the residuals. Of the major ports in the study area the model has overpredicted Matane by .236 and Rivière-du-Loup by .045, while underpredicting Rimouski by .171.

The only observation that could be interpreted as a slight trend is the occurrence of higher residuals in the upstream portions of the region. When the distance of each port from Quebec City is correlated with the size of its residual, a coefficient (rho) of .55 is obtained. [19] This trend could be taken as representing the error created by the exclusion of the land transport competition component from the model. It may be noted that the area west of Matane is the only region served by rail.

c) *Conclusion*

The study has examined some of the problems in measuring relationships between port activity on the south shore of the lower St. Lawrence River and a number of general factors put forward by earlier researchers. The poor performance of the hinterland variables has been noted already. This suggests that geographers should look more closely into the direct relationships usually proposed between the hinterland and port size.

Although other variables exhibited stronger associations, they may be questioned because of the suitability of the surrogates selected. Thus the effects of vessel size in port trade can be revealed only partly by gross vessel tonnage data.

A statistical model has been produced that accounts for over 90 per cent of variance in port activity in the study area. This must be regarded as a satisfactory performance. Such a model may have use as a tool in decision making and planning port investments. It clearly identifies ports whose trade

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[18] KING, L.J., *Opus cit.*, p. 169.

[19] Significant at the 99.5% confidence level.

performance is lower than expected. Many of the ports in the region are declining and it may be necessary for the Federal Government, as the major source of capital investment in port facilities, to rationalise its policies. By concentrating investments in ports that can be identified as being viable, the demise of the marginal ports may be hastened, while those with the potential to grow may be strengthened.

BIBLIOGRAPHY

BUREAU D'AMÉNAGEMENT DE L'EST DE QUÉBEC (1966) *Les Transports.* Mont Joli.

CANADA, Statistics Canada, *Census of Canada 1966.* Ottawa.

CANADA, Hydrographic Service (1966) *The St. Lawrence Pilot.* Ottawa.

COLE, J.P., and C.A.M. KING (1968) *Quantitative Geography.* London, John Wiley and Sons. 692 p.

HEAVER, T.D. (1968) *Economies of Vessel Size.* Ottawa.

KING, L.G. (1969) *Statistical Analysis in Geography.* Englewood Cliffs, New Jersey, Prentice Hall. 288 p.

OLSSON, G. (1965) Distance and Human Interaction. *Geografiska Annaler,* Vol. 47, pp. 3-43.

RIMMER, P.J. (1966) The Problems of Comparing and Classifying Seaports. *The Professional Geographer,* 18 (2) : 83-91.

Scott's Industrial Directory of Quebec (1966) Oakville, Ontario.

SLACK, B. (1972) *A Geographical Analysis of the System of Ports on the South Shore of the Lower St. Lawrence River.* Unpublished Thesis, McGill University, Montréal.

WEIGEND, G. (1958) Some Elements in the Study of Port Geography. *Geographical Review,* Vol. 48, pp. 185-200.

YATES, T.E., ed. (1967) *Stepwise Multiple Linear Regression.* Program Library, Oregon State University, Portland.

ABSTRACT

SLACK, B. : An Explanation of Port Activity on the South Shore of the Lower St. Lawrence River.

The study examines the factors that affect variations in port size in the region below Quebec City on the south shore of the St. Lawrence River. The investigation draws upon the results of earlier studies and measures the relationships between six factors and port size. Multiple regression analysis produces a model that accounts for over 90 per cent of size variation in the port system.

KEY WORDS : Port Activity, Explanatory Model, South Shore of the Lower St. Lawrence River, Quebec, Canada.

RÉSUMÉ

SLACK, B. : Essai d'explication du degré d'importance des ports de la rive sud de l'estuaire du Saint-Laurent.

Cette étude analyse les facteurs qui influencent la taille des ports situés en aval de Québec, sur la côte sud de l'estuaire du Saint-Laurent. Elle utilise les résultats des recherches antérieures sur la géographie portuaire et mesure les corrélations entre six facteurs et la taille portuaire. L'analyse de régression multiple propose un modèle qui rend compte de plus de 90% de la variance de la taille dans le système portuaire.

MOTS-CLÉS : Degré d'importance des ports, Modèle explicatif, Rive sud de l'estuaire du Saint-Laurent, Québec, Canada.