THE ECONOMIC IMPACT OF SHIPPING ON THE NATIONAL ECONOMY

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Introduction

The literature on the importance of shipping to a nation's economy is extensive. In both developed market economy countries and developing ones, the arguments have traditionally ranged from those relating to prestige and strategic considerations, to employment, infant industry protection and balance of payments benefits. However, yardsticks such as these fail to capture the indirect and induced effects of the shipping industry on the national economy and are thus of limited use for policy making purposes. This is particularly true nowadays when various assistance schemes to industry are increasingly scrutinised not only for their compatibility to competition law but also in the attempt of many countries to tighten government budgets.

As a method, *Input-Output Analysis* can go a long way towards quantifying the indirect effects of industrial activity on the economy. In the case of the United States, for example, it has been recently calculated that for every job in the merchant marine, 4.4 additional jobs are created in the economy, and for every dollar of household income in this sector, 3.4 dollars of additional income is created in the economy by and large. Similar results can be demonstrated for Holland where the method has also been successfully applied.

Along the same lines, I/O analysis can provide plausible answers to questions such as: if the government adopts a *laissez faire* policy to shipping, would the country continue to have a merchant marine? If not, to what extent would foreign-flag ships, now carrying the country's external trade, be beneficially owned by national shipowners (flagging-out)? What would be the effect of the policy on employment, the port industry and other sectors of the economy providing inputs to shipping? Are the economic benefits from any support scheme to shipping greater than what could have been achieved by supporting other sectors of the economy? What would be the effect on freight rates and thus on consumer welfare?

The European Commission, in the context of its Fourth Framework Programme, had commissioned a large-scale study for the evaluation of the economic impact of the shipping industries of the UK, Italy, Holland and Belgium. The purpose of this paper is thus to present the pertinent scientific aspects of the I/O methodology and its application to the shipping industry, and to discuss the policy implications that this approach entails[1].

[1] The research was undertaken by an international consortium of Universities and independent consultants from Belgium, Germany, Greece, Holland and the UK. The author of this paper is mainly involved in the scientific validation and extension of the I/O methodology, as it may apply in the maritime sector, and its policy implications. Parts or all of this paper may be eventually copyrighted by the European Commission. Comments are appreciated and can be sent to the author at the following address: Professor H.E. Haralambides, Faculty of Economics, Erasmus University Rotterdam, Burg. Oudlaan 50, 3062 PA Rotterdam, The Netherlands. This paper was presented at the International Association of Maritime Economists Conference, Vancouver, Canada, 1996.

Fundamentals of Input-Output Analysis

Input-Output Analysis (I/O) derives its name from the work of Wassily Leontief; work that earned him the Nobel Prize in economic science in 1973. As with Léon Walras a hundred years before him (1874) or even François Quesnay with his *tableau économique* (1758), Leontief's aim was to analyse in a systematic way the interdependence of a country's industrial sectors; in his case, those of the United States[2]. For this reason, the term *inter-industry analysis* is sometimes used. For obvious reasons, I/O analysis, known as *inter-branch balances*, was a powerful tool, from as early as the 1920s, in the planning exercises of the former Soviet Union[3]. In the United States, given the importance of inter-State commodity flows and other economic interdependences, the body of literature is vast, having appeared in almost all journals of regional economics[4]. Lately, the technique has come to be known under a variety of names such as *Economic Effects Analysis, Economic Impact Study Analysis*, etc[5].

The principle behind I/O analysis is simple: each industry[6] produces to satisfy the *final demand* for its *output* but also the *intermediate* demands of all other sectors in the economy that use this output as a factor of production (*input*). In this way, any exogenous change in the final demand for an industry's output -due to, say, a change in tastes, price, disposable income or government policy- will have an *impact* both on the industry itself *and* on all other sectors whose product the industry requires as an input. In their turn, the impacted sectors will demand more of their own inputs (and so on) and thus a "rippling effect" is generated and dispersed throughout the economy. By the time the "ripple" subsides, total spending exceeds the initial amount spent, total production exceeds production for final consumption, and total employment exceeds employment in the production of goods for final consumption. The power of I/O analysis is mainly in its ability to capture and summarise these multiplicative effects on output, household incomes and labour requirements.

However, economic impacts such as these measure the extent to which the industry in question is linked to the rest of the economy, but they do not measure economic gains from industry activity. In other words, estimates of the economic impacts of an industry are, with rare exceptions, measures of *gross*, not *net* impacts. A net impact would need to reflect all opportunities available elsewhere in the economy for the resources used directly by the industry and indirectly by all other industries. For example, if the demand for shipping were to decline and the services provided by the shipping industry were to decline, seafarers might remain employed in other maritime occupations or other industries. In this case, the provision of service by the merchant marine would not have resulted in a gain in national employment. Moreover, if the decline in service provided by the merchant marine did not affect the provision of port services and the production of other domestic goods and services because foreign-flag operators taking the place of national shipping operators would have used these goods and services, then the jobs associated with the provision of merchant marine service would not have been lost with the decline in service provided by the merchant marine. Hence, shipping would not have in-

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[2] W. Leontief, "Quantitative Input-Output Relations in the Economic System of the United States", *Review of Economics and Statistics*, 18, no 3, August 1936, pp. 105-125.
[3] H. Levine, "Input-Output Analysis and Soviet Planning", *American Economic Review*, 1962.
[4] Two thorough reviews of regional I/O models can be found in: K.R. Polenske, "*The U.S. Multi-regional Input-Output Accounts and Model*", Lexington, Mass., Lexington Books, 1980 and W.H. Miernyk, "*Regional Analysis and Regional Policy*", Cambridge, Mass., Oelgeschlager, Gunn & Hain Publishers Inc., 1982.
[5] Most interestingly for an academic methodology that dates back to the 18th century, one of these names has recently been deposited as a registered trademark!
[6] Hereafter the terms "sector" and "industry" are used interchangeably.

indirectly generated employment gains in other domestic industries[7].

Formally, the basic I/O table of an economy could be described by a system of simultaneous linear equations, each one detailing how an industry's output is distributed throughout the economy. These *inter-industry flows* are depicted in the shaded area of Figure I. The solution of the system provides estimates of the extent to which all industries are affected when the demand for the output of any one industry changes.

The distribution of each industry's output in the economy is found by reading horizontally across the relevant row. The origin of each industry's inputs can be found by reading vertically down the corresponding column. An industry may buy its own product as an input -flows appearing on the *main diagonal*- and these transactions are known as *intra-industry flows*[8]. For example, ocean shipping may be buying feedering services for the regional distribution of overseas cargoes. Slot-chartering arrangements in container shipping could be another example of this type of transaction.

An industry sells also to final demand, i.e. personal consumption, private investment and government, while a part of its output may also be exported. Apart from the required inter-industry flows, a sector uses, of course, other non-industrial inputs in its production such as labour, capital, entrepreneurship and government services. These are the rows labelled *value added* in Figure I.

The number of sectors included in the basic I/O table can vary from a few to hundreds or even thousands depending on the desired level of disaggregation and the particular problem at hand. For example, *shipping* can be considered as a single sector or it can be broken down to sub-sectors on the basis of ship type, size, flag, ownership, etc. Compiling an I/O table from survey data (known as the bottom-up approach) can thus be an expensive and time consuming exercise often resulting in the criticism that I/O tables are outdated by the time they are compiled. This criticism is however sometimes unjustified. A considerable body of research has reported on a remarkable temporal stability of I/O technical coefficients. Furthermore, rigorous techniques have also been developed (e.g. the RAS technique) to update I/O tables with minimum data requirements[9].

With the advent of inexpensive computing power, the computational requirements of I/O analysis have been eliminated. The methodology has thus become a widely used tool in policy evaluation. The United Nations is recommending it as a planning tool for developing countries and has sponsored a standardised system of economic accounts for the development of I/O models[10].

Although the methodology has been widely applied in the port sector of many countries around the world, in the case of shipping the only two countries known to have successfully used it are the United States and the Netherlands. But let us briefly see the place of the shipping industry in the simplified I/O table of Figure I. The examples are, of course, only indicative of the many different transactions that actually appear in each cell.

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[7] Nathan Associates Inc. "*Economic Analysis of Federal Support for the Private Merchant Marine*". Report submitted to the American Maritime Congress. Arlington, VA, January 1995.

[8] As a result of difficulties with measuring physical output, the inter-industry flows of goods and services in an I/O table are usually expressed in monetary terms.

[9] Erasmus University is working on the development of *partial survey* and *non-survey* techniques designed to address this problem.

[10] R.E. Miller and P.D. Blair, "*Input-Output Analysis*", Prentice-Hall, 1985. See also V. Bulmer-Thomas, "*Input-Output Analysis in Developing Countries*", John Wiley & Sons Ltd., 1982.

Among the other flows in the *shipping sector* row, shipping services are sold to agriculture for the transport of grains; manufacture for the transport of containers[11]; final consumers for recreation (cruises); government for the transport of government impelled (strategic) cargoes[12]. Finally, shipping services may be exported for the transport of goods between third countries (cross-trades) or even for servicing the country's external trade, whenever the foreign trade counterpart uses a domestic ship[13]. Looking down the *shipping* column, the industry buys victuals from agriculture; stores and spare parts from manufacture; finance and insurance from the service sector; cargo-handling services from the port sector. In addition, the industry rents office space, pays for government services, and it employs labour (manning costs), capital (interest payments) and entrepreneurship (profits).

If we denote by z_{ij} the value of output of sector i that is sold as an input to sector j, then in an n-sector economy total output of sector i (X_i) will be distributed throughout the economy as:

$$X_i = \sum_{j=1}^{n} z_{ij} + Y_i \qquad i=1,2,...,n \qquad (1)$$

where Y_i is sector i sales to final demand (consumption, investment, government and net exports).

This formulation assumes that the final demand for an industry's output is exogenous to the system i.e., determined by considerations independent of the industry's total output. Such a model is known as an *open* Leontief model. However, this is rarely the case; final demand for, say, consumer goods may indeed be determined by prices, tastes etc., but also by consumer income which is a function of output produced in the economy. Furthermore, income distribution has also a bearing on final demand. Given this interdependence between final demand and production, *closed* Leontief systems are often used, whereby parts (or even all) of total demand are considered as endogenous sectors and thus included in the basic inter-industry flows matrix through the addition of extra rows and columns[14].

The total output of industry i is also given as the sum of the elements of the corresponding column:

$$X_i = \sum_{j=1}^{n} z_{ji} + W_i \qquad i=1,2,...,n \qquad (2)$$

where W_i is the value added inputs used by the industry (labour, capital, entrepreneurship, rents etc.).

Simply, the elements of column i represent the outlays of that industry for the purchase of row material and other industrial inputs from other sectors of the economy, as well as for salaries, interest, and other value added inputs.

Total gross output in the economy, X, would thus be given by summing either (1) or (2) w.r.t. i:

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[11] More specifically, shipping services are bought for the transport of the country's CIF exports and FOB imports.
[12] One might consider the upkeep of the US reserve fleet as another example.
[13] H.E. Haralambides, "Shipping Transactions in the Balance of Payments Statistics: A Tabular Approach", *Marine Policy Reports*, Vol. 1, No 2, 1990.
[14] Completely closed Leontief systems are rarely found in practice. In such a case, the system of equations in (1) will be homogeneous and the columns of (***I***-**A**) linearly dependent. (***I***-**A**) will thus be singular and the method breaks down.

$$X = \sum_{i=1}^{n} X_i = \sum_{i=1}^{n}\sum_{j=1}^{n} z_{ij} + \sum_{i=1}^{n} Y_i = \sum_{i=1}^{n}\sum_{j=1}^{n} z_{ji} + \sum_{i=1}^{n} W_i \tag{3}$$

or

$$Y = \sum_{i=1}^{n} Y_i = \sum_{i=1}^{n} W_i = W \tag{4}$$

Equation (4) is the basic national accounts identity where W is *Gross National Income* (total factor payments in the economy) and Y is *Gross National Product* (total consumption expenditure, private domestic investment etc.).

One of the main shortcomings of I/O analysis is in its assumption of *constant returns to scale*. To see this, consider the typical *technical coefficient* defined as:

$$a_{ij} = \frac{z_{ij}}{X_j}, \qquad i,j = 1,2,...,n \tag{5}$$

This simple input-output ratio shows the monetary value of the product of sector i used as input in the production of a dollar's worth of output of industry j. In basic I/O analysis[15], once these technical coefficients have been calculated from observed data they are assumed to remain constant i.e., *economies of scale* are not allowed for, and factors are used in fixed proportions i.e., no factor substitution is possible in the sector's *production function*.

Seeing it from a different angle and abstracting from the value added inputs of Figure I, the figures of column j can be thought of as describing that industry's production function given by[16]:

$$X_j = \min_i\left(\frac{z_{ij}}{a_{ij}}\right), \qquad j=1,2,...,n \tag{6}$$

Employing matrix notation and letting $z_{ij}=a_{ij}X_j$, the system of equations in (1) can be written[17]:

$$\mathbf{X} = \mathbf{AX} + \mathbf{Y} \tag{7}$$

or

$$(\boldsymbol{I} - \mathbf{A})\mathbf{X} = \mathbf{Y} \tag{8}$$

where **X**, **Y** are the (nx1) total output and final demand vectors respectively, **A** is the (nxn) matrix of technical coefficients a_{ij} and ***I*** is the (nxn) identity matrix.
The solution to the system of the n linear equations in (8) is given by[18]:

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[15] as the method has so far been applied in the maritime sector.

[16] equation (6) is the standard notation for a fixed factor proportions production function. Although all z_{ij}/a_{ij} ratios should be equal to each other and to the industry's output, the "min" operand ensures that inputs not in use (a_{ij}=0) are not taken into account.

[17] boldfaced letters denote matrices and vectors. For readers unfamiliar with matrix notation and operations, the summation notation (Σ) is also used from here on in equations, parallel to matrix notation, to the extent possible.

$$\mathbf{X} = (\boldsymbol{I} - \mathbf{A})^{-1}\mathbf{Y} \qquad (9)$$

The typical α_{ij} element of the Leontief inverse $(\boldsymbol{I} - \mathbf{A})^{-1}$ gives the *impact* on industry i's output as a result of a change in the final demand of sector j i.e., $\Delta X_i = \alpha_{ij} \Delta Y_j$. Its importance lies in the fact that this coefficient captures *in a single number* a series of *direct* and *indirect* (multiplicative) effects.

Assume, for example, that the government plans to introduce a new fiscal facility aimed at switching cargo from road to short sea shipping and in this way relieve its congested motorways. Although the facility will cost a known amount of taxpayer money and affect output and employment in the trucking and related sectors in a multiplicative way, it will also have a series of positive effects as well. Medical, pollution abatement and other congestion related costs will go down in a measurable way. Furthermore if successful, the new policy will result in an initial increase in the demand for port, finance, insurance and other shipping related services, as well as labour, victuals, stores, bunkers, etc. Thus, the output of each of the impacted sectors will have to increase and this in its turn will have an impact on many other sectors whose output will be required as an input. The port sector may need more cargo handling equipment; the manufacturers of the latter (if domestically produced) will have to buy more steel; the steel industry will have to increase its purchases of iron ore and so on[19].

The method's power becomes thus apparent, particularly if combined with Cost-Benefit analysis[20]. In the above example the government can compare not only the negative effects on the trucking industry with the positive ones on shipping and the environment but, in an era of squeezed budgets, it can easily measure the backflow to the government (in terms of new and foregone taxes) and compare it with the costs of the fiscal facility itself.

Sometimes more importantly, all this will have an impact on employment whose increased earnings will, in their turn, result in increased consumer spending on goods and services[21]. Assume that the structure of employment in the economy is known, i.e. number of persons employed in each sector by type of employment. The typical element ε_{ij} of the employment coefficient matrix **E** would thus give the percentage of type i employees (e.g. maritime economists) employed in the entertainment sector j (i=1...k, j=1...n). The total effect on employment as a result of a change in final demand would thus be given by:

$$\hat{\mathbf{E}} = \mathbf{E}(\boldsymbol{I} - \mathbf{A})^{-1}\mathbf{Y}^{*} \qquad (10)$$

where $\mathbf{Y}^{*}$ is the new forecasted demand vector. The typical element of the calculated (kx1) *employment impact* vector $\hat{\mathbf{E}}$ shows the new requirements for a particular profession, e.g. maritime economists, as a result of anticipated changes in the demand for shipping, opera singers and jasmine tea. The importance of this information for vocational training and retraining needs as well as employment orientation policies is only too apparent.

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[18] provided of course that ($\boldsymbol{I}$-**A**) is non-singular and thus its inverse $(\boldsymbol{I}-\mathbf{A})^{-1}$, known as the *Leontief inverse*, exists. The non-singularity condition requires that the determinant $|\boldsymbol{I} - \mathbf{A}| \neq 0$

[19] As each industry will have to produce not only to satisfy the final demand for its own output but the demand of all other sectors that use its output as an input, the main diagonal elements of the Leontief inverse must be greater than one.

[20] see Nathan Associates *op. cit.*

[21] in Leontief systems closed w.r.t. households.

Multipliers in Input-Output Analysis

The calculation of the Leontief Inverse, $(\boldsymbol{I}\text{-}\mathbf{A})^{-1}$, can produce a number of useful summary measures known as *multipliers*. These are numerical expressions aimed at capturing the impacts of a change in final demand (e.g. government spending) on i) gross output in the economy, ii) household incomes and iii) generation of employment.

Multipliers are often categorised in *simple* and *total* multipliers depending on whether or not the Leontief system is closed to households. In open systems, multipliers capture the *direct* and *indirect* effects of a change in final demand. In closed systems, where households are considered an endogenous sector ("producing" labour and spending income), total multipliers capture also the *induced* effects of increased spending by households, due to their now higher incomes. As a result, the numerical value of a total multiplier is often significantly higher than that of the "simple" one.

Output Multipliers

Assume that the final demand for Short Sea Shipping (SSS) increases by \$1 as a result of government policy. ΔY(s) will thus be an (nx1) column vector with 1 at the "shipping" row and zeroes everywhere else. The impact of this change on the economy will be given by:

$$\Delta\mathbf{X}(\mathrm{s}) = (\boldsymbol{I} - \mathbf{A})^{-1}\Delta\mathbf{Y}(\mathrm{s}) \tag{11}$$

which should not be difficult to recognise as the sth (shipping) column of the Leontief Inverse. The simple output multiplier of the shipping sector is then defined as the column s sum given by:

$$\mathrm{O_s} = \boldsymbol{i}'(\boldsymbol{I} - \mathbf{A})^{-1}\Delta\mathbf{Y}(\mathrm{s}) = \sum_{i=1}^{n}\alpha_{is} \tag{12}$$

and, as already mentioned, it measures the direct and indirect effects on the whole economy as a result of a dollar change in the demand for shipping.

The total output multiplier of the shipping sector in a Leontief system closed for households is defined in an analogous way i.e.,

$$\overline{\mathrm{O}}_s = \boldsymbol{i}'(\boldsymbol{I} - \overline{\mathbf{A}})^{-1}\Delta\mathbf{Y}(\mathrm{s}) = \sum_{i=1}^{n+1}\overline{\alpha}_{is} \tag{13}$$

where $\overline{\mathbf{A}}$ is the (n+1)x(n+1) augmented matrix of technical coefficients defined as:

$$\overline{\mathbf{A}} = \left[\begin{array}{c|c} & \mathrm{H_{1C}} \\ \mathbf{A} & \vdots \\ & \mathrm{H_{nC}} \\ \hline \mathrm{H_{R1}} \cdots \mathrm{H_{Rn}} & \mathrm{h} \end{array}\right]_{(n+1)x(n+1)} \tag{14}$$

(the $\mathbf{H}'_R$ row vector of $\overline{\mathbf{A}}$ gives the required labour inputs (in money terms) in each sector; the $\mathbf{H}_C$ column vector presents household expenditures for each sector's output, and h could be considered as household purchases of labour services, e.g. for domestic help).

The total output multiplier of the US merchant marine was found equal to 3.4956 meaning that each dollar of additional demand for the services of the merchant marine generates 2.4956 additional dollars of output in all industries.

Income Multipliers

Income multipliers capture the effect of changes in final demand on incomes earned by households for providing their labour services to the production process.

It should be remembered that the typical element α_{is} of the "shipping" column $(\boldsymbol{I}-\mathbf{A})_s^{-1}$ of the Leontief Inverse measures the direct and indirect impact of $1 change in the demand for shipping on sector i output. In addition, sector i labour requirements per dollar of sectoral output are given by the H_{Ri} element of the augmented matrix of technical coefficients $\overline{\mathbf{A}}$. Therefore, the product $H_{Ri}\alpha_{is}$ gives the direct and indirect incomes generated in sector i as a result of a dollar increase in the demand for shipping.

Thus, the *simple* household income multiplier of the shipping sector, I_s, would be defined as:

$$I_s = \mathbf{H}_R^{'}(\boldsymbol{I}-\mathbf{A})_s^{-1} = \sum_{i=1}^{n} H_{Ri}\alpha_{is} \tag{15}$$

and it would capture the direct and indirect income effects on the whole economy due to a one dollar change in the demand for shipping.

If the system is closed w.r.t. households, direct, indirect and *induced* income effects on the economy can be summarised by the *total* household income multiplier of the shipping sector defined as:

$$\bar{I}_s = \left[\mathbf{H}_R^{'} \;\vdots\; h\right](\boldsymbol{I}-\overline{\mathbf{A}})_s^{-1} = \sum_{i=1}^{n} H_{Ri}\bar{\alpha}_{is} + h\bar{\alpha}_{n+1,s} \tag{16}$$

where $\bar{\alpha}_{n+1,s}$ gives the total monetary value of all labour inputs in the economy required to meet a dollar's increase in the final demand for shipping services[22].

Particularly for policy-making purposes, it is sometimes of interest to calculate the effect of a change in sectoral incomes (due to a change in sectoral demand) on total employment income in the economy. These multipliers are known as Type I and Type II income multipliers (for open and closed Leontief systems respectively) and are given by:

$$_{(I)}I_j = I_j / H_{Rj} \tag{17}$$

and

$$_{(II)}\bar{I}_j = \bar{I}_j / H_{Rj} = \bar{\alpha}_{n+1,j} / H_{Rj} \tag{18}$$

$_{(II)}\bar{I}_s$ can simply be interpreted as follows: a dollar increase in the final demand for shipping services, $\Delta Y(s)$, has an initial effect on that sector's household incomes, given by H_{Rs}. Once the

[22] It can be shown that $\bar{I}_s = \bar{\alpha}_{n+1,s}$; in other words, total household income multipliers can simply be found by just looking at the (n+1)th row of $(\boldsymbol{I}-\overline{\mathbf{A}})^{-1}$.

direct, indirect and induced effects on the economy, due to ΔY(s), have been translated into employment requirements (in value terms), measured by $\bar{I}_s$, the Type II income multiplier of the shipping sector ${}_{(II)}\bar{I}_s$ would give the total income in the economy generated as a result of a dollar increase in household earnings of the shipping sector.

In the case of the US merchant marine, this multiplier was found to be $4.4301 meaning that for each dollar of household income earned in the merchant marine, 4.4301 dollars are generated from employment in all industries.

Employment Multipliers
Employment multipliers are quite similar to the household income ones, their only difference being that, here, physical labour inputs (number of employees) are used instead of the value of labour services used in income multipliers. Sectoral employment coefficients can be obtained from labour statistics.

Let

$$\mathbf{L}' = \left[\lambda_1, \lambda_2, \cdots, \lambda_n\right] \tag{19}$$

represent the vector of physical labour inputs required in each sector to produce a dollar's worth of output and λ denote the number of domestic help employees per dollar of household expenditure[23].

The simple employment multiplier of the shipping sector would thus be given by:

$$E_s = \mathbf{L}'(\boldsymbol{I} - \mathbf{A})_s^{-1} = \sum_{i=1}^{n} \lambda_i \alpha_{is} \tag{20}$$

and it would measure the number of additional jobs in the economy required to meet a dollar's increase in the demand for shipping. In the same way, the total employment multiplier (capturing also the induced employment effects of the new household expenditures) would be:

$$\bar{E}_s = \left[\mathbf{L}' \;\vdots\; \lambda\right](\boldsymbol{I} - \bar{\mathbf{A}})_s^{-1} = \sum_{i=1}^{n} \lambda_i \bar{\alpha}_{is} + \lambda \bar{\alpha}_{n+1,s} \tag{21}$$

Type I and Type II employment multipliers can be calculated and interpreted in a way analogous to that of the corresponding household income multipliers, i.e.

$${}_{(I)}E_s = E_s / \lambda_s \tag{22}$$

and

$${}_{(II)}\bar{E}_s = \bar{E}_s / \lambda_s \tag{23}$$

For example, ${}_{(II)}\bar{E}_s$ would give the total number of new jobs created in the economy for every new job in the shipping sector. For example in the case of the US merchant marine, each job in the water transport sector creates 5.3874 jobs in all US industries. Income and employment Type I and Type II multipliers, sometimes known as *Total Direct-Effect Multipliers*, are quite

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[23] The ratios $\mathbf{H}_R^{'} / \mathbf{L}^{'}$ would thus give the average salary in each sector.

often preferred in I/O analysis, given that, in general, income and employment data are more readily available than data on final demand (required for the calculation of the simple and total multipliers as defined above).

Measures of Dispersion

It should be remembered that the typical output multiplier[24], O_j, captures the direct and indirect effects (output requirements) on the industrial output of the whole economy as a result of a dollar change in the final demand for the output of industry j. As such, output multipliers are important decision tools in the hands of the government: their comparison allows the latter to single out those industrial sectors with the highest impact on the economy or in other words those industries whose expansion draws the heaviest upon the rest of the economy. *Ceteris paribus* - and to the extent possible- public investment, fiscal facilities and state aid programmes of any kind should be directed towards these sectors.

As defined, however, output multipliers tell only part of the story. For purposes of policy evaluation, what is sometimes of greater importance is how a sector's impact is distributed (dispersed) throughout the economy. For example, it may be that an industry has a very high output multiplier but most industries will be left practically unaffected if the final demand for the products of that industry is increased. This can be the case when the industry in question draws heavily on one or just a few other sectors. At the same time, an industry with a lower impact can have effects that are more evenly dispersed in the economy. In such a case, how can the two sectors be ranked? In other words, how does a sector with a strong but concentrated impact score against another with a smaller but more evenly dispersed one? Obviously, the probability distribution of sectoral impacts should somehow be introduced into the picture.

The impact on a sector, chosen at random, due to a dollar change in the demand for shipping is derived from (12) as:

$$\tfrac{1}{n} O_s = \tfrac{1}{n} \boldsymbol{i}'(\boldsymbol{I} - \mathbf{A})^{-1} \Delta \mathbf{Y}(s) \;\; = \tfrac{1}{n} \sum_{i=1}^{n} \alpha_{is} \tag{24}$$

Furthermore, the impact on a sector, chosen at random, as a result of a dollar change in the final demand of a sector, again chosen at random, would be:

$$\tfrac{1}{n^2} \sum_{j=1}^{n} O_j = \tfrac{1}{n^2} \boldsymbol{i}'(\boldsymbol{I} - \mathbf{A})^{-1} \boldsymbol{i} \;\; = \tfrac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} \tag{25}$$

Rasmussen[25] defines the *Power of Dispersion* of sector s as the ratio of (24) to (25), i.e.

$$\pi_s = \frac{n \sum_{i=1}^{n} \alpha_{is}}{\sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij}} \tag{26}$$

[24] Although the notion of a *simple* output multiplier is used hereunder, the discussion is relevant for total output multipliers too.

[25] P.N. Rasmussen, "*Studies in Inter-sectoral Relations*", Einar Harcks Forlag, Copenhagen, 1956; North-Holland Publishing Company, Amsterdam, 1956. The same ratio has also been used by C. Peeters *et. al.* "*The Future of the Dutch Shipping Sector*", Delft University Press, 1994 (in Dutch).

A value of π_s greater than one means that, on average, the economy will need a comparatively large production increase to cope with a dollar increase in the final demand for shipping. In other words, $\pi_s > 1$ means that the shipping sector draws heavily (compared to the industries in general) on the system of industries -and *vice versa* for $\pi_s < 1$.

However, although Rasmussen correctly states that the Power of Dispersion index "*...expresses the extent of the expansion caused in the system of industries in general by an expansion in industry no. j...*", the index -at least in its simple form in (26)- provides no information as to how this expansion (impact) is dispersed in the economy[26].

To start with, the index in (26) suffers from all the shortcomings of unweighted averages: it assumes that sectoral impacts are dispersed uniformly throughout the economy; it also assumes that an increase in final demand is distributed evenly among all sectors -or even worse it assumes that an increase in final demand has the same effect on the economy regardless which sector it originates from-, and finally the index does not take into account the relative importance of each sector's output in the overall system of production.

Rasmussen's unsuccessful use of averages in (26) originated from his desire to introduce some measure of statistical dispersion in the index; something that he never really managed to do. To continue on the "shipping" example, a number of the above problems could be avoided if the Power of Dispersion index is redefined as the ratio of the total impact (direct and indirect) on the economy due to a dollar change in the demand for shipping, over the total impact on the economy due to a dollar change in final demand in general; in this case, however, the increase in final demand is distributed among the sectors according to their relative importance. Thus,

$$\hat{\pi}_s = \frac{\mathrm{YO_s}}{\boldsymbol{i}'(\boldsymbol{I} - \mathbf{A})^{-1}\mathbf{Y}} = \frac{\mathrm{YO_s}}{\sum_{j=1}^{n}\sum_{i=1}^{n}\alpha_{ij}\mathrm{Y_j}} = \left(\frac{\mathrm{Y}}{\mathrm{X}}\right)\mathrm{O_s} \qquad (27)$$

(substituting from (9)).

This result allows power of dispersion indices to be derived directly from the corresponding output multipliers through multiplication by the ratio of total final demand to total output. Being as it is, power of dispersion indices do not furnish any additional information other than what is already provided by output multipliers. Their usefulness is in describing how a certain industry scores *vis a vis* the rest of the economy. However, if the policy maker's interest is how an industry's impact compares to that of others, the simple observation and comparison of output multipliers would be quite sufficient.

To evaluate how an industry's impact is dispersed in the economy, output multipliers can be normalised through the use of the *coefficient of variation* notion borrowed from descriptive statistics[27]. According to this, the coefficient of variation of the impact of the shipping sector would be defined as:

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[26] Doing proper justice to the author it should be said that although he defines the term Power of Dispersion as in (26) above, what he really had in mind in calling it so was his refined (normalised) index; cf. p.135 ff. In Peeters *et. al.*, *op. cit.*, the study stops short at the use of the simple index in (26) and thus the use of the term Power of Dispersion is rather unfortunate.

[27] The coefficient is defined as the ratio of standard deviation to the mean of a probability (frequency) distribution. Cf. H. Cramér, "*Mathematical Methods of Statistics*", Princeton University Press, 1974, p.357.

$$V_s^{\pi} = \frac{n}{O_s}\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\alpha_{is} - \frac{O_s}{n}\right)^2} \qquad (28)$$

The new index shows how the impact of a dollar increase in the demand for shipping is dispersed throughout the economy or in other words the extent to which the shipping industry draws evenly on the system of industries. The index can thus be useful for inter-industry comparisons: assuming a *balanced growth* strategy is desirable, and that the government has still something to say in the allocation of scarce resources in the economy, activity should be encouraged, one way or the other, in those sectors with the highest coefficient of variation.

A measure similar to that of power of dispersion, fraught however with the same problems, is *sensitivity of dispersion*. Consider the sum of the sth (shipping) row of the Leontief inverse $\sum_{j=1}^{n}\alpha_{sj}$; this amount gives us the output requirements posed on the shipping industry if the economy as a whole is to meet an increase in final demand of n dollars, distributed equally in each sector. In a way analogous to (27), the weighted sensitivity of dispersion index of the shipping sector is here defined as:

$$\hat{\sigma}_s = \frac{\frac{Y}{n}\sum_{j=1}^{n}\alpha_{sj}}{\boldsymbol{i}'(\boldsymbol{I}-\mathbf{A})^{-1}\mathbf{Y}} = \frac{Y}{nX}\sum_{j=1}^{n}\alpha_{sj} \qquad (29)$$

Obviously, $\hat{\sigma}_s > 1$ means that the shipping industry will in general have to increase its output more than other industries for a given increase in demand. In other words, the index shows the extent to which the economy as a whole draws upon the shipping sector. In this case, the use of the term "sensitivity" is appropriate given that the index measures how sensitive the particular industry is to changes in demand[28].

Properly defined, power and sensitivity of dispersion indices can be powerful tools in policy-making. If power of dispersion indices can be thought of as being useful in the development of long-term balanced growth strategies, the sensitivity of dispersion ones could provide valuable information for the development of short-term anti-cyclical policies. Indeed, for such policies, every government would like to know which of its industries are more sensitive to change, in terms of creating additional output, employment and incomes.

[28] The manner in which the industry's output is distributed in the economy can be demonstrated in a way similar to (28). The derivation of the relevant variation formula is left to the reader as an exercise.

Conclusions And Policy Implications of Input-Output Analysis

An even cursory look over the past 150 or so years of modern maritime history would suggest that, with a few notable exceptions, no maritime nation with a "genuine link" between ownership and registration of its ships has ever been able to develop and maintain a national flag fleet without recourse to some sort of protectionism. Such interventions have taken the form of cargo reservation, flag discrimination, differential port dues and ship operating subsidies, shipbuilding subsidies, various other fiscal facilities and, last but not least, the institutionalised participation in shipping through the cargo-sharing arrangements of the UN Code of Conduct for Liner Conferences.

More often than not, however, protectionism in any of its forms incurs substantial *economic* costs in terms of the ensuing inefficient resource allocation, higher prices, reduced consumer surplus and personal consumption possibilities.

Being as it may, governments favourably inclined towards these types of intervention in shipping must evidently have some rather compelling reasons for doing so. Arguments in favour have at times included considerations of economic and military security and independence, safeguarding of the "common interest", balance of payments effects, creation of employment, preservation of maritime know-how and the maintenance and development of the shipping-related maritime infrastructure.

The problem with many of these arguments, however, is that they are difficult to quantify (and rank) without recourse to some rather bold assumptions. Still, sometimes quite justifiably, these arguments carry significant weight in the arena of political decision-making. For example, arguments on the necessity for economic security and independence -through the preservation of tonnage under the national flag- are often put forward by countries in order to also argue that a national flag fleet can be easier made to conform with national expectations regarding safety standards and citizens' increased environmental awareness.

On the other hand, arguments that are relatively easy to quantify, such as balance of payments effects and creation of employment, are not convincing enough to make a strong case for protectionism. The balance of payments criterion for example has been excessively used in the literature as a good reason for developing and maintaining a merchant marine: The substitution of domestic ships for the foreign ones previously used to carry the country's external trade would save foreign exchange payments for freight transportation and, furthermore, the domestic fleet would be able to earn additional foreign exchange by cross-trading.

In this light, however, the shipping industry cannot be treated any differently than other export-oriented industries, or even industries producing "tradable" goods and services. In addition, the acquisition and/or saving of foreign exchange is not an economic benefit in itself apart from cases where i) the opportunity cost of foreign exchange exceeds its nominal value (predominantly the case of developing countries) and ii) the impact of foreign exchange from shipping on a country's balance of payments is so pronounced (for example in the case of Greece) that this source of income can have a discernible effect on the exchange rate and on general economic and balance of payments policy.

To take on the argument of "employment creation", despite its positive and measurable impacts, the creation of seafaring employment cannot be a strong argument for maintaining and promoting shipping. This is not only because of the nowadays relative unattractiveness of the seafaring profession, but mainly due to the fact that shipping is a capital-intensive industry whose Labour/Capital ratio compares unfavourably to that of other industries. This disadvantage is compounded by the increase in size and automation of modern ships that significantly reduce labour requirements.

For example in 1960, the Labour/Capital ratio of the Greek bulk shipping industry was 2.8 seafarers per 1000 GRT, while presently the ratio does not exceed the value of one. In liner shipping this effect is even more pronounced: In 1968, a first generation container vessel of 740 TEU was employing ten licensed officers and 24 ratings while in 1992, a fourth generation container vessel of 4400 TEU was employing only seven multi-purpose officers and seven qualified ratings.

A problem with both arguments presented above (balance of payments and creation of employment) is that they fail to capture the indirect and induced effects on the economy due to the operations of the shipping industry. Something that could be easily done through the use of I/O analysis. Employment in the U.S. merchant marine is a good example to follow up on this.

In 1992, although only 8,514 seafarers were directly employed in the merchant marine, the land-based support personnel in 412 maritime establishments totalled 11,314 people; i.e., 57% of maritime employment was land-based[29]. But the story does not of course end here; through its multiplicative effects on the economy, the U.S. merchant marine created an additional 86,993 jobs dispersed throughout the economy. In total, 106,821 direct, indirect and induced jobs exist in the U.S. economy as a result of the existence of the merchant marine. Furthermore, although in the same year the total wage bill of the 19,828 maritime employees amounted to only $1,027 million, the significant multiplier effects of the merchant marine raised total income in the economy by $4.5 billion. As a result, the backflow to the government in the form of personal income taxes amounted to $587 million; an amount more than adequate by itself to finance the federal government's direct outlays in support of its cargo preference[30] and ODS scheme[31].

Some of the results of the analysis of the impact of the U.S. merchant marine, the cargo preference and the ODS programmes on the U.S. economy are summarised in Table I.

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[29] Nathan Associates, *op. cit.* This result compares with a similar one for Holland where it was shown that 70% of the value added of shipping is created by land-based activities. See Debisschop *et. al.*, *op. cit.*

[30] Three principal laws specify cargo preference requirements (see Nathan Associates, *op cit.*): The Cargo Preference Act of 1904, which requires that all items procured for or owned by the military be carried exclusively on U.S.-flag ships; the Cargo Preference Act of 1954, which requires that 75% of U.S. government concessional food-aid cargoes and at least 50% of all other non-military government-generated cargoes be transported on privately owned, U.S.-flag, commercial vessels, and Public Resolution 17 of the 73rd Congress, which requires that all cargoes generated by the EXIM Bank be shipped on U.S.-flag vessels (the latter requirement may be partially waived by MARAD to allow ships of recipient countries to carry part of the trade generated by an individual loan).

[31] The Merchant Marine Act of 1936 authorised the federal government to pay an Operating Differential Subsidy to U.S.-flag ships used in foreign trade. The subsidy covers no more than the difference between U.S. and foreign crew wage costs and, in some ODS contracts, the differential costs of protection and indemnity insurance, hull and machinery insurance and maintenance and repairs not covered by insurance. The subsidy is meant to assist U.S.-flag ships in competing on an equal footing with foreign-flag vessels.

Table I Impacts of the Merchant Marine on the U.S. Economy

	Merchant Marine	***Cargo Preference***	***ODS***
Direct, Indirect and Induced U.S. Employment	107,000	40,000	31,000
Direct, Indirect and Induced Household Earnings ($billion)	4.5	2.2	1.6
Direct, Indirect and Induced Federal Income Tax Revenues ($million) (Dollars per Dollar of Government Outlay)	738 (NA)	354 (1.26)	268 (1.24)
Foreign Exchange ($billion)	3.8	1.2	0.9

Source: Nathan Associates 1995

What is of interest to note in this table is that the combined effect of the two support measures (cargo preference and ODS) is greater than the sum of the two individual effects. Furthermore, the employment figures in the table could be interpreted by saying that the liberalisation of the market for “strategic” and other cargoes presently set aside by law for the U.S. merchant marine (cargo preference) would cost the country 40,000 jobs and $354 million in tax revenues. On the other hand, the possibly lower freight rates -as a result of liberalisation- would not have any discernible effect on the market for strategic cargoes, as this trade is not market driven. In the same way, the abolition of the Operating Differential Subsidy -mainly meant to equalise manning costs with those prevailing in third countries- would cost the country 31,000 jobs and $268 million in tax revenues.

The above illustrative example demonstrates the power of I/O analysis in policy evaluation. For example, the same table shows that for every dollar of government outlay in support of the ODS, the government has a return of 24 cents (26 cents for the maintenance of the cargo preference scheme).

Even more importantly however, the method’s usefulness is to be found in its ability to rank order the impacts of sectoral economic activity, such as shipping, *vis a vis* the corresponding impacts of other industrial sectors. This can be an important criterion -but definitely not the only one- in deciding whether a particular economic activity ought to be promoted. (In this context, unfortunately, neither of the two studies referred to above addressed the issue of whether the benefits of government support to shipping are greater than the benefits that could be attained by other government support programmes (current or contemplated) for other sectors of the economy).

These impacts, or *backward linkages*, measure the extent to which the shipping industry draws upon the other sectors of the economy or region for the production of its services. In other words, the extent to which shipping can stimulate other industrial activity and thus employment and economic growth. Sectors depending on the shipping industry include ports, finance and insurance, brokerage and ship-management services, shipbuilding and repairs, equipment, stores and provisions, bunker fuel, real estate and telecommunications. Clearly, the more the shipping industry is involved in servicing the country’s external trade (direct trades *vis a vis* cross-trading) the greater these impacts will be. Also, the higher the percentage of overheads in total shipping costs (e.g. liner shipping) the higher the impact on the economy.

In a number of cases, such as for example from the point of view of the European Union, these impacts could be brought into clearer perspective and be better appraised through the use of a European I/O table. By such an approach it could, for example, be shown that although the impact of Greek shipping on the Greek economy may not be as large as one would expect from an industry of this size[32], nevertheless Greek shipping contributes substantially to the corresponding earnings of the City of London as well as of those of Cyprus, although the latter country is not yet a member of the European Union. A "15 plus" effect would thus be created, showing that "the total is larger than the sum of its parts", and efforts *towards a new maritime strategy*[33] could be effectively consolidated.

In addition to measuring impacts, the concise presentation of output multipliers in simple matrix form (the Leontief Inverse) allows the evaluator to appraise the degree of evenness with which these impacts are dispersed throughout the overall system of industries. In other words, whether, in the course of producing its output, an industry draws heavily on one or just a few other sectors, or whether its impacts are more evenly distributed. The policy implications of such information are significant.

However, the most important aspect of I/O analysis is its ability to translate changes in final demand into output and employment requirements. For example, knowing the potential productive capacity of the economy, I/O tables can give significant indications as to the extent to which interest rates can be lowered in order to stimulate economic activity without inciting inflation. Or, the extent to which the initial effects of a competitive devaluation on a country's trade balance are transformed into output growth and employment. In principle, any macroeconomic policy effectively influencing aggregate demand can thus be appraised in terms of its total (direct, indirect and induced) impact on employment and growth[34]. In the case of the U.S. merchant marine it was estimated that each dollar increase in the final demand for shipping services produces 2.5 dollars of extra output in the U.S. economy.

In lieu of a critique

As with any other methodology, I/O analysis is not void of shortcomings. The assumption of constant returns to scale in industrial production functions can be a first cause for concern, particularly if dated I/O tables are used without adjustment for the impact of technological change. Having said that, however, it should also be said that considerable progress has been made over the years in updating I/O tables with limited data requirements, while in a number of cases it has been shown that inter-temporal I/O tables demonstrate a remarkable stability.

Dynamic I/O analysis -accounting for temporal capital consumption- has proven to be an awkward corner and in a number of cases it has been shown that the methodology can completely break down. Further applied research is required to demonstrate whether observed errors and divergence between static and dynamic analysis are significant enough to justify more emphasis on dynamic analysis.

As I/O analysis is mainly concerned with industrial linkages and inter-industry commodity flows, it cannot account for non-market valuations that are equally important in policy evaluation. This is perhaps the reason why I/O analysis has never been applied to evaluate the effectiveness of military expenditures. In the same way, I/O analysis can very effectively measure the economic impact of privatisation but it cannot alone give answers to a government's concerns regarding income distribution and accumulation of wealth, as a result of privatisation. A combination of Input-Output and Cost-Benefit analysis is required in such cases.

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[32] currently 18% of world merchant tonnage.

[33] see Commission of the European Communities, "*Towards a New Maritime Strategy*", COM(96) 81 final, Brussels, 13 March 1996.

[34] As a matter of fact, macroeconomic modelling can give equally plausible answers to most of the issues addressed by I/O analysis. An evaluation of the two methods' relative merits falls outside the scope of this paper and in any case the preferred method will depend on the problem under investigation (by stating this, however, the severe lack of "one-handed economists" is acknowledged for one more time).

In most cases, estimated impacts are *gross* impacts of economic activity and as such they fail to identify alternative employment opportunities for the human, material and financial resources used by the industry under examination and all other industries linked to it. A combination with Cost-Benefit analysis can again give meaningful policy recommendations, by distinguishing between impacts, economic benefits and costs. To use the “creation of employment” argument again, “employment” *per se*, despite its positive impacts, is an economic cost rather than an economic benefit (otherwise societies would be willing to pay people for digging and filling ditches); it is only the goods and services that this employment produces (and society is willing to pay for) plus the value that society attributes to the preservation of a certain know-how that can be considered as an economic benefit.

In cases where I/O analysis is used for long-term planning and allocation of scarce resources, the plausibility of any of its results is crucially dependent on correct model specification and econometric forecasting of future final demand. Depending on the problem at hand, national or international econometric forecasting models must be interconnected to I/O tables and policy scenarios developed in this way.

The above shortcomings by no means reduce the method’s usefulness in policy analysis and evaluation, and economic planning. Once the method’s limitations are known, the evaluator can weigh economic impacts against his other policy evaluation criteria, thus arriving at a politically acceptable and hopefully consistent policy mix. At any rate, in today’s complex economic environment, being able to measure something, even with a degree of error, can only be preferable to a state of vagueness and uncertainty. In his seminal work on the strategy of economic development[35] Hirschman convincingly argued that *economic development is constrained by a shortage of decision-making ability, particularly with respect to decisions to invest*. In many countries, I/O analysis has gone a long way towards rectifying this, and for that reason the United Nations is recommending I/O analysis as a planning tool for developing countries. Especially if combined with Cost-Benefit analysis and econometric modelling, I/O techniques can indeed become a most powerful policy tool.

[35] A.O. Hirschman “*The Strategy of Economic Development*”, Yale University Press, 1958 and also P.A. Yotopoulos and J.B. Nugent “A Balanced-Growth Version of the Linkage Hypothesis: A Test”, Quarterly Journal of Economics, Vol. LXXXVII, No. 2, 1973.