Merchant Fleet Size versus External Trade and other relevant variables: A Statistical Investigation

by

PETER B. VRANAS

Submitted to the Department of Ocean Engineering
in partial fulfillment of the requirements for the degrees of

MASTER OF SCIENCE IN OCEAN SYSTEMS MANAGEMENT

and

MASTER OF SCIENCE IN OPERATIONS RESEARCH

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 1991

Author ....
Department of Ocean Engineering and Operations Research Center
May 10, 1991

Certified by ....
Henry S. Marcus, Thesis Supervisor
Associate Professor of Marine Systems

Certified by ....
Arnold I. Barnett, Thesis Reader
Professor of Operations Research and Management

Accepted by ....
A. Douglas Carmichael, Chairman
Graduate Committe, Department of Ocean Engineering

Accepted by ....
Amedeo R. Odoni, Chairman
Graduate Committe, Operations Research Center

Merchant Fleet Size versus External Trade and other relevant variables: A Statistical Investigation

by

PETER B. VRANAS

Submitted to the Department of Ocean Engineering
on May 10, 1991, in partial fulfillment of the
requirements for the degrees of
MASTER OF SCIENCE IN OCEAN SYSTEMS MANAGEMENT
and
MASTER OF SCIENCE IN OPERATIONS RESEARCH

Abstract

The object of this thesis is the investigation of the size of the merchant fleet of various important maritime nations. The investigation is conducted in two parts: the *synchronic* study, dealing with data for a single year, and the *diachronic* study, dealing with time-series data. The analytical tool used in the thesis is linear regression theory. The synchronic study establishes that controlled fleet is a better measure of fleet size than flag fleet and that deadweight tonnage is a better measure of fleet size than number of vessels. The synchronic study also establishes that, among ordinary economic indices, it is Gross Domestic Product that has the highest explanatory power when controlled fleet deadweight tonnage is the explained variable, and that external trade, measured as either imports or exports or their sum, comes second in explanatory power. The diachronic study gives first indirect support for the hypothesis that, although in recent years the flag fleets of several maritime nations have dramatically decreased, this decrease has been compensated by a corresponding increase of the foreign flag portion of the controlled fleets of these nations. Then the diachronic study shows that, for the nations having experienced this decrease of flag fleet, a linear regression model with flag fleet as the explained variable and GDP and exports as the explanatory variables has little explanatory power, while for the remaining nations the same model has quite good explanatory power. It follows that, for the latter group of nations, the regression equations given in the diachronic study may be useful for prediction purposes.

Henry S. Marcus, Thesis Supervisor
Associate Professor of Marine Systems

Arnold I. Barnett, Thesis Reader
Professor of Operations Research and Management

Acknowledgments

I would like to thank my thesis supervisor, Pr. H. S. Marcus, for suggesting the topic and for assisting me throughout the whole project. I would also like to thank my thesis reader, Pr. A. I. Barnett, for his insightful comments.

This thesis is dedicated to my parents, as a small recognition of what they have done for me and of what they are feeling towards me.

Contents

List of Tables

Chapter 1

Introduction.

This introductory chapter consists of two sections. In the first section I define the problem which is the object of the thesis, I state the objectives of the thesis with respect to that problem, and I give a plan of the whole project. In the second section I briefly describe some statistical notions which are frequently used in the body of the thesis, namely regression analysis and hypothesis testing.

1.1 The problem.

Very roughly stated, the topic of this thesis is the investigation of the size of the merchant fleet of various nations. "Investigation" can be understood in at least two senses, depending on whether one is interested in the past or in the future. With respect to the past, investigation is explanation: why did the merchant fleets of various nations have the sizes they had at various points in time? With respect to the future, investigation is prediction: how can we best predict the sizes that the merchant fleets of various nations will have at various points in time? These two topics are usually interrelated, since the past behaviour of a system is almost universally relevant to its future behaviour.[1]

Explanation requires an *explanandum* (i.e., something to be explained), an *ex-*

[1] This remark applies also to Markov chains, because "past" is meant to include the present.

planans[2] (i.e., something which explains), and a method of explanation (similar remarks hold for prediction). In the present case the *explanandum* is obviously merchant fleet size, but it is not so obvious how merchant fleet size is to be described. Should one measure it in terms of the number of ships in the fleet or in terms of the total fleet deadweight tonnage? Should one take into account the vessels that are registered under the flag of the country under consideration ("flag fleet") or the vessels whose effective ownership is in the hands of citizens of the country under consideration ("controlled fleet")? How should one choose the nations whose fleets are to be examined?

There are two ways in which such questions can be answered. One way is to settle them in advance by means of extraneous considerations, or even by arbitrary decisions. Thus, one could decide to look only at the fleets of the United States and of its major trading partners. Or one could be interested only in the fleets of the most important maritime nations. Another way to answer these questions is by taking into account the tractability of the resulting problem. If, for instance, one has at one's disposal methods which perform excellently when the variable to be explained is the fleet size measured in deadweight tonnage, but perform terribly when the variable is fleet size measured as number of vessels, then one has strong (though not necessarily conclusive) reason to opt for the former definition of fleet size.

These considerations show, I think, that the above questions are better left unanswered for the moment. They will be answered in the course of the thesis. It is true that the resulting *a priori* specification of the problem is not as precise as one could wish, but we are trying to deal with a real-world issue rather than with some simplified mathematical model of the issue (although simplified mathematical models will inevitably have to be used).

Concerning now the *explanantia*, it is clear that one can't know in advance what these will be, and their determination will be an important task of the thesis. There is, however, one prominent candidate for explanatory value: the size of the external trade of the nation under consideration. Again, it is unclear how external trade should

[2] Or several *explanantia*.

be defined (imports? exports? imports+exports?), so this question will have to be examined in the sequel. Other plausible explanatory variables include Gross Domestic Product (GDP), Trade Balance, and other economic indices. An explanatory factor which probably has much importance are the maritime policies of the nations under consideration, but these seem difficult to quantify.

Concerning finally the method of explanation, it will be statistical theory, and, more specifically, linear regression theory. Linear regression is a very well developed and more or less standard approach to a great number of economic and other problems. Because it is so well developed, it is easy to implement it and to interpret its results. Of course, linear regression is not always applicable, but its use is so widespread that one has recourse to other methods (e.g., nonlinear regression) only when one has theoretical reason to think either that some nonlinearity is inherent in the problem or that the assumptions of the linear model are violated. There seems to be no reason to expect a nonlinearity for the problem we are interested in, but we will have to examine if the assumptions of the linear model can be plausibly taken to be satisfied in our case.

The above remarks concerned the delimitation of the problem. Now the purpose of this thesis is to attack the problem in a rigorous quantitative way. The plan of the thesis is as follows. The second section of Chapter 1 gives some statistical preliminaries essential for an understanding of the remainder of the thesis. Chapter 2 deals with the so-called *synchronic* study, referring to a given time instant. This time instant was chosen as the most recent year for which data were available, namely 1989.[3] The purposes of the synchronic study are: to find the best definitions of the variables of interest, in order to sharply define the problem; to find which variables have significant explanatory power; and to quantify the explanatory power of the significant variables. The results of Chapter 2 are presumably relevant for prediction purposes, although the prediction would be in terms of a general trend concerning a set of nations pooled together, rather than individual nations. Chapter 3 deals with

[3]This is also the *only* year for which data on controlled fleets are available, as explained in Section 3.1. For some variables, 1989 data were not available, so data for the latest available year were used instead.

the so-called *diachronic* study, referring to a series of time instants. The time series chosen starts at 1969 and goes up to 1987.[4] The purposes of the diachronic study are: to test the specific hypothesis that, over the recent years, the marked decrease in the flag fleet of several nations has been compensated by a corresponding increase of the foreign flag fleet, so that the controlled fleet has remained more or less constant; to find linear relationships (useful for prediction purposes) between merchant fleet size and the explanatory variables; and to classify nations according to the explanatory power of the regressions. Finally, Chapter 4 summarizes the conclusions of the thesis.

A word of caution, before we embark upon our enquiry. We are dealing with a complicated real-world problem, the investigation of the merchant fleet size of various nations. We shouldn't be very optimistic at the outset about finding excellent explanations, much less about becoming able to make very trustworthy predictions.

1.2 Statistical preliminaries.

In this section I will first describe the standard linear model used in regression analysis. I will examine whether the assumptions of this linear model can be reasonably taken to be satisfied in our case. Then I will give some results from the statistical theory of hypothesis testing; these results are relevant to the problem of determining whether or not some variable in a regression model has significant explanatory power. The descriptions will be brief and without proofs; I will mostly limit myself to results which will be actively used in the body of the thesis.

Regression analysis and hypothesis testing are very highly developed, and there is a large body of literature concerning them. For the purposes of this thesis, only relatively elementary notions, such as found, e.g., in *Basic Econometrics*, by Damodar Gujarati (McGraw-Hill, 1978), will be needed. For a more advanced and rigorous (although not exceedingly formal) treatment of the main topics in statistics, the interested reader is referred to *Statistical Theory*, by Bernard W. Lindgren (3rd edition, Macmillan, 1976).

[4]With some gaps in between, corresponding to years for which some data were not available.

1.2.1 Linear regression.

Consider a variable Y, the *dependent* variable, or the variable to be explained. In our case, Y is merchant fleet size (vaguely stated). Consider also a set of variables $X_1, ..., X_p$, the *independent* or *explanatory* variables. In our case, these include external trade, gross domestic product, etc. Now the linear regression model postulates that these $p+1$ in total variables are related in the following way:

$$(1)\ \ Y = \sum_{j=1}^{p} \beta_j X_j + E,$$

where $\beta_1, ..., \beta_p$ are coefficients to be determined and E is a variable representing an error term. The purpose of linear regression is the following: given a sample of n values of each of the variables $Y, X_1, ..., X_p$, find a "best" estimate of the unknown coefficients $\beta_1, ..., \beta_p$. In our case, the sample consists either of the values of the variables for various nations at a given point in time (synchronic study) or of the values of the variables for a given nation at various points in time (diachronic study). If we represent by y the column vector consisting of the n values of Y appearing in the sample, by X the (n,p) matrix whose j-th column consists of the n values of X_j appearing in the sample, by β the column vector of the unknown coefficients, and by ϵ the column vector of the errors, then we have the folllowing relation in matrix notation:

$$(2)\ \ y = X\beta + \epsilon.$$

Now the *least-squares* estimator b of β is given by the following formula:

$$(3)\ \ b = (X'X)^{-1}X'y,$$

where X' denotes the transpose of the matrix X and $(X'X)^{-1}$ denotes the inverse of the square matrix $X'X$. This estimator arises from minimising the sum of the squares of the residuals $Y - Xb$, this is why it is called the "least-squares" estimator.

Various assumptions are usually made about the above classical linear model, and one gets various results according to the assumptions one makes. Since we are primarily interested in hypothesis testing, we will need all of the following assumptions. First, the rank of the matrix X is p. In other words, the columns of the matrix X are linearly independent, so that there is no linear dependence in any set of explanatory variables. As an example of what linear dependence would be, suppose we included the following three explanatory variables in the model: imports, exports, and the sum of imports and exports. Since the third variable is equal to the sum of the first two, the three variables are linearly dependent and the first assumption of the classical linear model is violated. This situation is called *multicollinearity*. This example shows that it is not always a good thing to include as many variables as possible in the model: if one tried to find whether external trade should be represented as imports, exports, or their sum, it would be a bad method to include all three variables in the model in order to compare their performance.

The second assumption is that the random error vector ϵ is normally distributed with mean zero and covariance matrix $\sigma^2 I$, where σ is an unknown constant and I is an identity matrix. Actually, this formulation incorporates several distinct assumptions: first, that the distribution of all error terms is normal; second, that the mean value of all error terms is zero; third, that the variances of all error terms are identical (and equal to σ^2); and fourth, that the covariance of any two error terms is zero. Can these assumptions be reasonably taken to be satisfied in our case? I see no reason to believe that the normality or the zero-mean assumption will pose a problem. The *homoscedasticity* (i.e., equal variance) assumption is sometimes likely to be violated in cross-sectional (rather than time-series) data, and this suggests that there might be a problem with the synchronic study, since the latter deals with data for various nations at a given point in time. Would we expect the variances of the error terms to be higher for nations with bigger fleets? It is not clear why nations with bigger fleets, rather than nations with bigger external trades, or bigger gross domestic products, should have higher variances. There are methods for dealing with the problem of *heteroscedasticity*, but I think that their consideration would constitute an unnecessary digression, this is why I will consider homoscedasticity satisfied. If it were not, then the statistical tests performed in Chapter 2 would be less powerful, and this would imply that maybe some variables without explanatory power will be included in the model, rather than that any variables with explanatory power will be excluded.[5] This is a reasonable risk to take, provided that, as I do in Chapter 2, one is careful to include in the model only the few explanatory variables whose explanatory power is beyond question. Finally, the zero-covariance (i.e., no *autocorrelation*) assumption is sometimes violated in time-series, so maybe we shouldn't take it for granted as far as the diachronic study is concerned. But, as will be seen in Chapter 3, the size of our time-series is so small (13 or 14) that we can't apply the classical Durbin-Watson test for autocorrelation, since the tables for the d-statistic used in that test start from sample size 15. I will, therefore, also assume the no autocorrelation assumption to be satisfied.

A final assumption of the linear model is that the matrix X is non-stochastic. There are weaker forms of this assumption, such as that X is stochastic but distributed independently of ϵ. This assumption is introduced for mathematical convenience, and I will consider it satisfied in the sequel.

A *simple* linear regression is a regression with only one explanatory variable (plus, possibly, a second constant variable, corresponding to the *intercept*). A useful quantity relating to a given simple linear regression is the *coefficient of correlation*, which is defined as:

$$(4) \quad R = \frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \overline{X})^2 \sum_{i=1}^{n}(Y_i - \overline{Y})^2}},$$

where X_i are the values of the single explanatory variable X and $\overline{X}$,$\overline{Y}$ are the sample means of X and Y. The coefficient of correlation has the following interesting properties. It can be positive or negative, indicating a positive or negative sample *covariation* of X and Y. It lies between the limits of -1 and 1; the higher its absolute value, the higher the degree of covariation. It is independent of origin and scale, so that we can express our variables in any units we like. Note, however, that a high coefficient of correlation doesn't necessarily imply any cause and effect relationship.

[5] Because, usually, using formula (3) in the presence of heteroscedasticity will result in overestimating the t-statistic values (see next subsection). On this point, see Gujarati, *op. cit.*, section 10.2 (especially p.199).

A related useful quantity is the *coefficient of determination*, which is the square of the coefficient of correlation. For a *multiple* linear regression, i.e., a regression with more than one explanatory variables, the coefficient of determination (or *R-squared*) is generally defined as the ratio of the *explained sum of squares* over the *total sum of squares*. The total sum of squares is $\sum_{i=1}^{n}(Y_i - \overline{Y})^2$, which is a measure of the total sample variation of the dependent variable. Recall that we are estimating y by Xb, where b are the least-squares estimates of β. Therefore, the part of the total variation which is explained by the regression (i.e., the explained sum of squares), is given by the same formula as the total sum of squares but with the i-th component of Xb in the place of Y_i. A perfect linear regression would explain all the sample variation of the dependent variable, resulting in a coefficient of determination equal to 1. Generally, R-squared takes values between zero and one, and it expresses the percentage of the total variation in Y explained by the regression model. The coefficient of determination is a useful tool for comparing regression models, but it has a major shortcoming: it is a nondecreasing function of the number of explanatory variables present in the model. This means that, if we add *any* variable to a model, the coefficient of determination almost invariably increases and never decreases. In view of this, R-squared is inappropriate for comparing regression models with the same dependent variable but different numbers of explanatory variables. In order to deal with this difficulty, one defines the *adjusted R-squared*, $\overline{R}^2$, in the following way:

$$(5) \quad \overline{R}^2 = 1 - (1 - R^2)\frac{N-1}{N-p}$$

The adjusted R-squared is appropriate for comparing regression models with diferent numbers of explanatory variables. In contrast with R-squared, the adjusted R-squared can be negative, in which case it is considered to be zero.

1.2.2 Hypothesis testing.

I will very briefly describe two statistical tests which I will use in the body of the thesis: the F-test and the t-test.

The F-test (or test of Fisher-Snedecor) is designed to test the null hypothesis that the regression model as a whole has no explanatory power, i.e., that all regression coefficients β_j are equal to zero. This will rarely be the case, but it is good to begin a statistical investigation by checking that the proposed model is at least not widely off the mark. The F-test is based on the F-statistic, defined as follows:

$$(6)\quad F = \frac{R^2}{1-R^2}\frac{n-p}{p-1}$$

The basic result is that, given the null hypothesis, the F-statistic follows an F-distribution with $p-1$ and $n-p$ degrees of freedom. It follows that we can calculate the probability of getting a value of the F-statistic higher than that actually obtained from the sample, given the hypothesis that the model has no explanatory power. If this probability is sufficiently low, then we reject that hypothesis.

The t-test (or test of Student) is designed to test the null hypothesis that a specific independent variable has no explanatory power at all, i,e., that its regression coefficient is zero. Therefore, this test is particularly relevant for the purpose of constructing a model. The t-test is based on the t-statistic, defined as follows for variable X_j:

$$(7)\quad t = \frac{(b_j-\beta_j)\sqrt{\sum_{i=1}^{n} X_{ij}^2}}{s}$$

where s is the least-squares estimator of σ, and X_{ij} is the i-th sample value of variable X_j. The basic result is that, given the null hypothesis, the t-statistic follows a t-distribution with $n-p$ degrees of freedom. It follows that we can calculate the probability of getting a value of the t-statistic greater in absolute value than that actually obtained from the sample, given the hypothesis that the variable under consideration has no explanatory power. If this probability is sufficiently low, then we reject that hypothesis.

Chapter 2

Synchronic study.

In this chapter I examine linear regressions explaining, for various nations, merchant fleet size in terms of external trade and other relevant variables by using data for a single year, namely 1989.[1] These data are presumably recent enough for the results of the investigation to be of practical interest in terms of understanding the present situation and of extrapolating into the future. Interesting conclusions can also be drawn from data concerning a series of years, and such data are examined in the next chapter.

The plan of this chapter is as follows. In the first section, I explain the considerations motivating the choice of nations to be examined. In the second section, I exploit simple linear regressions of merchant fleet size versus external trade only, in order to see what is the explanatory power of the single explanatory variable "external trade". Finally, in the third section, I exploit multiple linear regressions in order to find which other variables (apart from external trade) are relevant to explaining merchant fleet size, and what is the gain in explanatory power resulting from including these additional variables in the regressions.

[1] More precisely, some data for 1989 were not available, so I used data for the latest available year instead.

2.1 Choice of nations.

A natural set of nations to examine is the set of the 35 nations classified by UNCTAD as "most important maritime countries"[2]. These countries are determined according to the size of their controlled fleet (deadweight tonnage) and are listed in Table 2.1.[3] A vessel is included in the controlled fleet of a nation exactly when that nation is the location of the controlling interest of the vessel, in terms of the parent company. As pointed out by the compilers of the *Review of Maritime Transport*, the determination of the location of the controlling interest has required, in several cases, certain judgements to be made. Note that vessels controlled, e.g., by Greek owners need not be making *any* calls to Greek ports. Note also that, given the above definition of controlled fleet, "flags of convenience" are not included, because vessels registered under a "flag of convenience" country are typically controlled by owners located in another country.[4]

The 34 most important maritime countries listed in Table 2.1 have together 92.24% of the total world controlled fleet and about 83% of the total world external trade (more precisely, 83.45% of exports and 82.27% of imports). It seems, therefore, that we can ignore the remaining countries without significant loss. Note also that the first 5 most important maritime countries (Greece, Japan, United Srtates, Norway, and USSR) control together 50.17% of the total world fleet through national flag and "off-shore" registers.

In order to check for internal consistency, I also ran some of the regressions using an alternative set of nations.[5] This alternative set consists of those among the 34 most important maritime countries that satisfy the following two conditions:

[2]United Nations Conference on Trade and Development, *Review of Maritime Transport, 1989*, New York: United Nations, 1990, p.8.

[3]With the exception of Taiwan Province of China, for which data concerning external trade and other variables were not available.

[4]The countries having flags of convenience ("open-registry" countries) are: Bahamas, Bermuda, Cyprus, Liberia, and Panama. Among these countries, only Cyprus makes it to the list of the really important maritime countries enumerated in Table 2.1.

[5]This alternative set of nations has been used in: Henry S. Marcus, Daniel H. Stahl, Christopher N. Nikoi, *U.S.-Owned Merchant Fleet: The Last Wake-Up Call?*, Massachusetts Institute of Technology, 1991 (Draft).

1	Greece
2	Japan
3	United States
4	Norway
5	USSR
6	Hong Kong
7	United Kingdom
8	China
9	Republic of Korea
10	Fed. Rep. of Germany
11	Italy
12	Brazil
13	India
14	Denmark
15	Iran
16	Singapore
17	Cyprus
18	France
19	Yugoslavia
20	Spain
21	Turkey
22	Romania
23	Belgium
24	Netherlands
25	Sweden
26	Poland
27	Kuwait
28	Philippines
29	Finland
30	Australia
31	Canada
32	Switzerland
33	Pakistan
34	Argentina

Table 2.1: The 34 most important maritime countries (see text of Section 2.1).

1	Japan
2	United States
3	Norway
4	United Kingdom
5	Fed. Rep. of Germany
6	Italy
7	Denmark
8	France
9	Belgium
10	Netherlands
11	Sweden
12	Finland
13	Australia
14	Canada
15	Switzerland

Table 2.2: Alternative set of nations (see text of Section 2.1).

1. They have a per capita gross domestic product (GDP) of over $9,500.[6]
2. They are classified by the United Nations as developed market economies.

These restrictions give us the set of the 15 countries listed in Table 2.2.

2.2 Fleet size versus external trade: simple linear regression.

In this section I run some simple linear regressions in which the dependent (explained) variable is merchant fleet size and the only independent (explanatory) variable is external trade. The purpose of running these simple linear regressions is twofold. First, it is interesting to see how high a coefficient of correlation we can get in this simple case, in order to have a measure of comparison with the case in which further explanatory variables are involved (see next section). Second, by comparing the coefficients of correlation arising from running the simple regression under various definitions of the variables "merchant fleet size" and "external trade", we can decide which are the

[6] *UNCTAD Statistical Pocket Book*, New York: United Nations, 1989.

most appropriate definitions to be used in the sequel. More specifically: as noted in Chapter 1, it is not clear whether fleet size should be measured in terms of number of vessels or in deadweight tonnage, or whether only the flag fleet or the total controlled fleet should be considered; and it is not clear whether external trade should be measured as imports, exports, or the sum of imports and exports. One might have some intuitive ideas about which of these definitions of the variables under consideration it would be preferable to adopt, but running the various regressions under all possible combinations of these definitions and comparing the resulting coefficients of correlation should provide a rigorous way to find the most appropriate definitions.

The data used in this section are summarized in Table 2.3. The data concerning fleet sizes come from the *Review of Maritime Transport, 1989* (United Nations Conference on Trade and Development, New York: United Nations, 1990, Table 5 (p.13)).[7] The data on imports and exports come from the *Handbook of International Trade and Development Statistics, 1989* (United Nations Conference on Trade and Development, New York: United Nations, 1990, Tables 1.1 and 1.2, (pp.2–11)).

There are 12 possible regressions of fleet size versus external trade, arising from the 4 possible ways in which fleet size can be defined (flag fleet in vessels, flag fleet in DWT, controlled fleet in vessels, controlled fleet in DWT) in combination with the 3 possible ways in which external trade can be defined (imports, exports, imports+exports). The coefficients of correlation for all 12 regressions appear in Tables 2.4, 2.5, and 2.6.

Note again that each of these 12 regressions concerns data for 34 countries but only for one specific year, namely 1989. The fact that all coefficients of correlation come out positive shows that, as expected, there is a positive correlation between Fleet Size and External Trade: the higher the trade, the bigger the fleet. Note also that, as noted in Chapter 1, the existence of a correlation does not necessarily imply a cause and effect relationship.[8]

---

[7]Note that the flag fleets for which data are given in Table 2.3 include only the controlled-fleet portion of the total flag fleets of the countries under consideration, and thus differ slightly from the total flag fleets. Only for Cyprus, an open-registry country, is the difference significant.

[8]I chose to compare results for the coefficient of correlation rather than its square, the coefficient

Country	Flag vsls	Cont vsls	Flag kdwt	Contr kdwt	Exp. (M$)	Imp. (M$)	Ex+Im (M$)	Fuel Imp.
Greece	984	2296	37002	80171	5307	12015	17322	1781
Japan	1212	2739	35874	72805	264959	187343	452302	38300
Un.States	810	1415	22257	59796	322224	459565	781789	44033
Norway	679	1177	24603	45484	22511	23222	45733	1197
USSR	4039	4039	28440	28440	110559	107229	217788	2044
Hong Kong	56	600	2765	27386	63163	63896	127059	1214
Un.Kingdom	474	889	9420	24685	145151	189471	334622	10036
China	1315	1449	18143	23582	47650	55361	103011	170
Rep. Korea	428	526	11166	14256	60696	51811	112507	5975
Fed.Germany	415	847	3930	12820	323277	250443	573720	19173
Italy	539	577	10473	10993	127114	138665	265779	16621
Brazil	304	309	9527	10304	33787	14604	48391	5404
India	383	400	9928	10256	13248	19150	32398	4299
Denmark	323	514	6643	10183	27140	25942	53082	1667
Iran	142	145	8613	8632	10600	9454	20054	43
Singapore	188	343	4458	7291	39305	43862	83167	6171
Cyprus	75	97	5444	7265	709	1857	2566	183
France	202	271	3988	6285	167792	178026	345818	16855
Yugoslavia	271	293	5594	5932	12597	13154	25751	2328
Spain	347	408	5300	5585	40067	60576	100643	6889
Turkey	319	335	4931	5473	11608	14380	25988	3172
Romania	335	338	5421	5442	13000	9000	22000	
Belgium	80	150	2486	5340	92787	92579	185366	7682
Netherlands	409	570	3154	5248	103561	99800	203361	9077
Sweden	183	276	1791	4660	49888	45734	95622	3160
Poland	329	329	4205	4205	13956	12240	26196	2320
Kuwait	43	62	2631	3960	7161	5352	12513	41
Philippines	226	240	3276	3489	7035	8731	15766	1152
Finland	95	159	769	3352	22151	21843	43944	2007
Australia	73	95	2763	2956	32734	33245	65979	1315
Canada	221	276	799	2886	112863	107736	220599	4254
Switzerland	15	95	338	2735	50861	56640	107501	2084
Pakistan	33	82	519	2705	4497	6590	11087	1026
Argentina	154	163	2423	2575	9135	5322	14457	500

Table 2.3: Data on fleet size and external trade for the 34 most important maritime countries.

IMPORTS	Number of vessels	Deadweight tonnage
Flag fleet	22.77	28.50
Controlled fleet	34.53	42.77

Table 2.4: Coefficients of correlation (in %) for fleet size versus imports.

EXPORTS	Number of vessels	Deadweight tonnage
Flag fleet	25.18	30.03
Controlled fleet	39.80	41.92

Table 2.5: Coefficients of correlation (in %) for fleet size versus exports.

2.2.1 Number of vessels or deadweight tonnage?

It is clear from the results shown in Tables 2.4, 2.5, and 2.6 that defining fleet size in terms of deadweight tonnage rather than number of vessels always results in a greater coefficient of correlation, no matter whether flag fleet or controlled fleet is taken into consideration, and no matter how external trade is defined. This comes probably as no surprise, given the fact that, in the merchant fleets of most nations, a large percentage of the total deadweight tonnage is taken up by a relatively small number of very big vessels, mostly oil tankers. For example, in 1989, 37.17% of the total world merchant fleet deadweight tonnage was constituted by tankers.[9] Given these considerations, it is deadweight tonnage that will be taken as a measure of Fleet Size in the sequel.

of determination, because coefficients of determination are smaller numbers, so that the differences in their magnitudes are smaller and they are more difficult to compare. Results on coefficients of determination are given in the next section.

[9] *Review of Maritime Transport, 1989, op. cit.*, Annex III(b), p.68.

IMP+EXP	Number of vessels	Deadweight tonnage
Flag fleet	24.29	29.68
Controlled fleet	37.62	43.00

Table 2.6: Coefficients of correlation (in %) for fleet size versus imports+exports.

2.2.2 Flag fleet or controlled fleet?

It is also clear from the results of Tables 2.4, 2.5, and 2.6 that defining fleet size in terms of controlled fleet rather than flag fleet always results in a *much* greater coefficient of correlation, no matter whether number of vessels or deadweight tonnage is taken into consideration, and no matter how external trade is defined. In fact, a typical increase in a coefficient of correlation when shifting from flag fleet to controlled fleet is about 0.12-0.13, whereas a typical increase when shifting from number of vessels to deadweight tonnage is only about 0.05. This difference in increases is so large that, as can be seen from the above tables, no matter how external trade is defined, the coefficients of correlation always follow the increasing order: flag fleet in number of vessels, flag fleet in deadweight tonnage, controlled fleet in number of vessels, controlled fleet in deadweight tonnage. The difference in explanatory power between flag fleet and controlled fleet can probably be accounted for by the fact that, in recent years, the flag fleet of various important maritime nations has declined, while the foreign flag portion of the controlled fleet may have had counterbalancing effects (this hypothesis is examined and validated in Section 3.1, by using data for a series of years). The importance of foreign flag vessels in fleet size is made evident by the fact that, in 1989, 43% of the total world merchant fleet deadweight tonnage was constituted by foreign flag vessels (i.e., foreign flag portions of controlled fleets).[10] The corresponding percentage for total world merchant fleet in number of vessels was only 30.4%. This difference is presumably due to the fact that a big percentage of foreign flag vessels is constituted by very large ships such as oil tankers. This explanation is validated by the following fact: in 1989, 49.8% of the foreign flag fleet (in DWT) of nine important maritime countries was constituted by oil tankers[11], compared with (as noted in the previous subsection) 37.17% for the total world national flag fleet. Given these considerations, it is controlled fleet that will be taken as a measure of fleet size in the rest of this chapter.

[10] *Ibid.*, Table 5, p.13.
[11] *Ibid.*, Table 6, pp.14–15.

	Imports	Exports	Imp+Exp
Flag fleet (vessels)	22.77	25.18	24.29
Flag fleet (DWT)	28.50	30.03	29.68
Controlled fleet (vessels)	34.53	39.80	37.62
Controlled fleet (DWT)	42.77	41.92	43.00

Table 2.7: Coefficients of correlation (in %) for linear regressions of fleet size versus external trade.

2.2.3 Imports, exports, or total?

The results of Tables 2.4, 2.5, and 2.6 show no significant difference in the coefficients of correlation when imports, exports, or their sum is taken into consideration. This is seen more clearly by rearranging the results as in Table 2.7.

Actually, in three of the four cases exports give the best (highest) coefficients of correlation, but the differences are rather negligible in all cases. This is probably because, generally, nations try to maintain a balance between imports and exports, so that the imbalances that inevitably occur are, in most cases, a small percentage of the total value of imports or exports. Moreover, the positive balances of some nations tend to cancel the negative balances of other nations. For instance, in 1988, the total exports for developed market economy countries were 1,985,500 M$, whereas the total imports were 2,078,600 M$[12]. It follows that it doesn't matter very much which definition we adopt for external trade. In the rest of this chapter, I will equate external trade with exports.

The conclusion of this section is that it seems best to adopt as a measure of fleet size the controlled fleet in deadweight tonnage, whereas it doesn't seem to matter very much whether one adopts as a measure of external trade imports, exports, or their sum.

[12] *UNCTAD Handbook of international trade and development statistics, op. cit.*, Tables 1.1 and 1.2, pp.2–3.

2.3 Fleet size versus a set of variables: multiple linear regression.

In this section I run some multiple linear regressions where the dependent (explained) variable is fleet size and the independent (explanatory) variables include, but are not restricted to, external trade. I adduce first some considerations motivating the choice of variables included in the regression. Then I present the results in terms of the adjusted coefficient of determination, which I compare to the results of the previous section in order to have a measure of the gain in explanatory power resulting from the inclusion of the additional variables. After that I perform some statistical tests in order to determine which regression coefficients are significantly different from zero, i.e., which variables should be really included in the model. Finally, I find the best subset of variables to be retained, and I test the results by running again some regressions for the alternative set of 15 nations.

2.3.1 A comprehensive set of variables.

It is difficult to determine *a priori* which variables one should take into consideration in order to explain merchant fleet size. External trade was an obvious choice, but no other choices are so obvious. This is why I opted for starting with a set of variables as comprehensive as possible, and I chose the following variables: exports, growth rate of exports, total real gross domestic product, per capita real gross domestic product, growth rate of total real gross domestic product, growth rate of per capita real gross domestic product, trade balance, and trade balance as a percent of imports. These variables seem to include most of the commonly used ordinary economic indices. One can suspect that, much more than these economic indices, the individual maritime policies of the different nations (when such policies exist) will play a significant role in determining merchant fleet size but, unfortunately, it is not easy to quantify these maritime policies.

The explained variable is merchant fleet size. An alternative idea would be to consider as explained variable per capita fleet size. Unfortunately, it turns out that per capita fleet size leeds to terrible regressions. This is shown in Appendix A. Alternatively, instead of considering the impact of population by taking per capita fleet size to be the dependent variable, one could stick with total fleet size and include population as an independent variable. I also show in Appendix A that population turns out to be clearly insignificant as an explanatory variable.

The new data used in this section come from the *UNCTAD Handbook of international trade and development statistics, 1989*, and are summarized in Table 2.8.[13] Note that full data for USSR, Romania and Iran were not available, and this reduces our sample size to 31 countries.

2.3.2 Finding the significant variables.

I ran the regression with 1 explained and 8 explanatory variables based on the data of Tables 2.8 and 2.3. I repeat that, from the latter table, I used the data for the controlled fleet in deadweight tonnage, as well as the data for the exports. The results can be summarised as follows.

The value of the F-statistic for the whole regression (cf. Section 1.2) is 3.346, and the probability of having a higher F value given that the model has no explanatory power at all is 0.0117. This probability is sufficiently low to enable one to reject the hypothesis that the model, as a whole, has no explanatory power at all.

The coefficient of determination of the regression (R-squared) is 54.885%. This can be compared with the coefficient of correlation of the simple linear regression in the previous section. That coefficient (cf. Table 2.7) was 41.92%. But note that the coefficient of determination is the *square* of the coefficient of correlation, so that the last number must be squared in order to be directly comparable with our current result. The result is 16.362% for the simple linear regression. We see that the current value of 54.885% is much higher, so that the inclusion of the additional variables has led to a considerable increase in explanatory power. The reader may recall from

[13] GDP and related data are for 1987; data for the remaining variables are for 1988.

Country	Export growth	Tr.bal. (M$)	Tr.bal./ Imports	GDP (G$)	Capita GDP($)	GDP growth	capGDP growth
Greece	-18.8	-6708	-55.8	46	4637	4.0	3.5
Japan	15.6	77616	41.4	2373	19453	5.7	5.2
Un.States	26.8	-137341	-29.9	4463	18429	4.6	3.7
Norway	4.7	-711	-3.1	84	20103	1.1	0.9
USSR	2.5	3330	3.1			4.4	3.4
Hong Kong	30.3	-733	-1.1	46	8045	7.5	5.7
Un.Kingdom	10.6	-44320	-23.4	681	12123	4.1	4.1
China	20.5	-7711	-13.9	293	274	11.2	9.9
Rep. Korea	28.4	8885	17.1	121	2842	11.3	9.5
Fed.Germany	9.9	72834	29.1	1116	18402	3.7	3.9
Italy	2.5	-11551	-8.3	756	13167	3.9	3.8
Brazil	28.8	19183	131.4	303	2141	-0.3	-2.3
India	14.2	-5902	-30.8	249	317	9.0	7.1
Denmark	6.0	1198	4.6	101	19763	-0.4	-0.4
Iran	-3.6	1146	12.1				
Singapore	37.0	-4557	-10.4	20	7606	11.0	9.8
Cyprus	14.2	-1148	-61.8	4	5455	6.9	5.8
France	17.0	-10234	-5.7	882	16047	3.5	3.2
Yugoslavia	10.3	-557	-4.2	63	2666	-1.0	-1.6
Spain	17.3	-20509	-33.9	289	7412	5.0	4.3
Turkey	13.9	-2772	-19.3	68	1322	3.6	1.5
Romania	6.7	4000	44.4			3.2	2.5
Belgium	11.6	208	0.2	139	13999	4.3	4.2
Netherlands	11.5	3761	3.8	213	14581	2.7	2.4
Sweden	11.3	4154	9.1	161	19323	2.3	2.5
Poland	14.3	1716	14.0	64	1694	4.9	4.2
Kuwait	-15.4	1809	33.8	20	9874	3.0	-1.2
Philippines	26.4	-1696	-19.4	34	601	6.7	4.3
Finland	13.2	308	1.4	89	18103	5.2	4.9
Australia	23.7	-511	-1.5	196	12180	3.3	2.0
Canada	19.6	5127	4.8	411	15849	4.4	3.4
Switzerland	11.2	-5779	-10.2	171	26772	3.2	3.2
Pakistan	10.0	-2093	-31.8	35	333	7.0	4.7
Argentina	43.6	3813	71.6	81	2564	-3.2	-4.6

Table 2.8: Data on various variables for the 34 most important maritime countries.

Chapter 1 that the adjusted R-squared is a better measure than the simple R-squared for the explanatory power of the regression when one compares regression models with different numbers of explanatory variables. The adjusted R-squared for the simple regression of the previous section was 13.478%, and for the current regression it is 38.480%. This is again a very considerable increase.[14]

We can then safely conclude that some of the new variables have explanatory power, but the question now becomes: which of the 7 additional variables have the most explanatory power and which set of variables should be finally retained in the model?

As a first step towards answering this question, I performed the t-test (cf. Section 1.2) on the regression coefficients of the 8 variables of the model. The results are summarized in Table 2.9.

Table 2.9 gives the following results. The hypothesis that the variable has no explanatory variable (i.e., its regression coefficient is not significantly different from 0) must be rejected for the following variables: Gross Domestic Product, export growth, and exports. For all these variables, the probability of getting a t value (in absolute

[14]My thesis reader suggested that I also include in the model fuel imports as an explanatory variable. Data on fuel imports are shown in the last column of Table 2.3. I ran first four simple linear regressions of fleet size versus fuel imports, corresponding to the four possible definitions of fleet size. The coefficients of correlation were: 14.39% for flag fleet in vessels, 39.91% for flag fleet in deadweight, 34.10% for controlled fleet in vessels, and 52.23% for controlled fleet in deadweight. Comparing these results with the numbers in Table 2.7, we see that fuel imports as a measure of external trade have a peculiar status: they do much better than imports or exports when fleet size is measured in deadweight tonnage (either as flag fleet or as controlled fleet), but they do much worse than imports or exports when fleet size is measured in number of vessels (either as flag fleet or as controlled fleet). This is presumably because fuel is carried by large tankers, which constitute a large part of total fleet deadweight tonnage but a small part of the total number of vessels. I then ran a multiple linear regression with fuel imports as an additional explanatory variable (so that the regression had a total of 9 explanatory variables). The adjusted coefficient of determination of that regression was 36.262%, which is slightly lower than the value of 38.480% I got without fuel imports. More seriously, the t-test showed the coefficient of fuel imports to be insignificant, with an exceedance probability of 0.6331. In order to eliminate possible multicollinearity effects due to the presence of both exports and fuel imports in the model, I also ran a multiple linear regression with fuel imports *instead* of exports as an explanatory variable (so that the regression had again a total of 8 explanatory variables). The adjusted coefficient of determination turned out to be 31.699%, quite lower than the previous value. Moreover, almost all t-exceedance probabilities deteriorated (i.e., increased) as compared to those in Table 2.9. In particular, the probability for fuel imports was 0.3560, so that the coefficient of fuel imports was again insignificant. I conclude that it isn't advisable to include fuel imports in the model, although they have, when considered alone, a high degree of correlation with fleet size measured in deadweight tonnage.

Explanatory variable	t-statistic	Prob. of higher $\|t\|$
Exports	-1.847	0.0782
Export growth	-2.187	0.0397
Trade balance	1.453	0.1604
Trade balance/Imports	0.231	0.8192
Gross Domestic Product	3.564	0.0017
Per capita GDP	-0.942	0.3563
GDP growth	-1.395	0.1768
Per capita GDP growth	1.572	0.1303

Table 2.9: t-tests on the coefficients of the multiple linear regression for 31 of the 34 most important maritime countries.

value) higher than what we got, given that the variable has zero regression coefficient, is very low, below 10%. On the other hand, the corresponding probability is very high for the following variables: trade balance/imports, and per capita GDP. These two variables seem therefore to have no explanatory power. For the remaining three variables (trade balance, GDP growth, and per capita GDP growth), the corresponding probability is not very high but not very low either: it is about 15%. We can't therefore draw any confident conclusion concerning these three variables.

Before attempting to interpret these results, we can go one step further in the quantitative analysis. What I did was to run the above regression for all possible subsets of the set of the explanatory variables, and then to rank the resulting regressions, for any fixed subset size, according to their adjusted R-squared values. For instance, Table 2.10 gives the best regressions with only one explanatory variable, i.e., simple linear regressions. For example, the row of Table 2.10 corresponding to Exports gives the adjusted R-squared of the regression in which Exports are the only explanatory variable; this value is 13.478%, as mentioned above.

The variables appearing in Table 2.10 are precisely those for which we concluded, based on the t-tests, that their regression coefficients for the multiple regression are significantly different from 0; therefore, we have here a further confirmation of our previous result. The remaining 5 variables give a negative adjusted R-squared and were not included in Table 2.10.

Explanatory variable	Adjusted R-squared
Gross Domestic Product	28.378
Exports	13.478
Export growth	2.785

Table 2.10: Best linear regressions with 1 explanatory variable.

Explanatory variables	Adjusted R-squared
GDP, Export growth	36.779
GDP, Trade balance/Imports	27.995
GDP, Trade balance	27.375
GDP, Exports	26.892

Table 2.11: Best linear regressions with 2 explanatory variables.

Table 2.11 gives the best regressions with 2 explanatory variables. Some interesting remarks can now be made. Note first that the best adjusted R-squared which we can achieve with 2 variables is 36.779%, which is significantly higher that the 28.378% which we can achieve with only 1 variable, but is insignificantly diferent from the 38.480% that we can achieve with all 8 explanatory variables together. This means that some of the 8 explanatory variables don't have explanatory power, and we will have to throw them away. Second, note that Gross Domestic Product appears, by all available evidence until now, to have by far the greatest explanatory power. GDP has the best performance in the t-test (Table 2.9), it has by far the best performance in the simple linear regressions (Table 2.10), and it is included in all best regressions with two explanatory variables (Table 2.11). Third, the fact that, in Table 2.11 the regression with Exports appears only in the fourth place doesn't seem to have any real significance, because the differences in the values of the adjusted R-squared in the last three rows of Table 2.11 are very slight. The last remark applies also to Table 2.12, which gives the ranking of regressions with 3 explanatory variables.

Table 2.12 also shows what can be confirmed by our previous results, namely that

Explanatory variables	Adjusted R-squared
GDP, Export growth, Per capita GDP growth	36.712
GDP, Export growth, Per capita GDP	36.409
GDP, Export growth, GDP growth	36.238
GDP, Export growth, Exports	35.999

Table 2.12: Best linear regressions with 3 explanatory variables.

Var	Explanatory variables	Adj.R2
4	GDP,Export gr.,Exports,Trade bal.	38.929
5	GDP,Export gr. Exports,Trade bal.,Per cap.GDP gr.	40.838
6	GDP,Export gr.,Exports,Trade bal.,Per cap.GDP gr.,GDP growth	41.286

Table 2.13: Best linear regressions with 4, 5, and 6 explanatory variables.

export growth seems to have significant explanatory power. We can also see that the maximum value of the adjusted R-squared for regressions with 3 variables is actually lower than the value for regressions with 2 variables (36.712% versus 36.779%), but the difference is too small to have any real significance.

The best regressions with 4,5, and 6 variables are given in Table 2.13. It can be seen that GDP, exports, and export growth are firmly established and that the next variables to appear are the three variables for which the t-test didn't give conclusive results: trade balance, per capita GDP growth, and GDP growth. The only two variables which don't appear in the best regression with 6 variables are the two variables for which we positively concluded, on the basis of the t-test, that they should be rejected: trade balance and per capita GDP. Also note that the value of the adjusted R-squared for the best regression increases only slightly as the number of variables increases.

Let us summarize the results of this long quantitative investigation. First, the most important explanatory variable seems to be Gross Domestic Product. Second, the only other important explanatory variables seem to be exports and export growth. Third, it is unclear whether or not trade balance, GDP growth, and per capita GDP growth have explanatory power. Finally, it seems that trade balance/imports and per capita GDP don't have any explanatory power.

What sense can we make out of these results? The first result wich requires explanation is the exceptional performance of Gross Domestic Product as an explanatory variable. The explanation does not seem very difficult. It is clear from Table 2.8 that countries with high GDPs have important fleets. The countries in Table 2.8 are arranged in descending order of their fleet size. Among the countries with the 10 biggest fleets, 3 (Japan, US, Germany) have GDPs larger than one trillion dollars, 4 have GDPs between 100 billion and 1 trillion dollars, and only 3 have GDPs lower than 100 billion dollars. In the next 10 biggest fleets, the picture changes: no countries have GDPs bigger than 1 trillion, 6 have GDPs between 100 billion and 1 trillion, and 4 have GDPs lower than 100 billion. Finally, in the last 10 biggest fleets, the picture changes again: 4 countries have GDPs higher than 100 billion and 6 have GDPs lower than 100 billion. All this is by way of explaining the intuitively clear result that large (i.e., high GDP) countries have big fleets.

But why is the per capita GDP insignificant, if the GDP itself is so significant? The simple answer is that a lot of rich (i.e., high per capita GDP) countries are small (i.e., have small population), so that their GDP is low. Take again a look at Table 2.8. You will see a more or less even distribution of per capita GDPs: among the countries with the 15 biggest fleets, 7 have a per capita GDP higher than \$10,000, and among the countries with the 15 "smallest" fleets, 7 again have a per capita GDP higher than \$10,000. The latter include such rich but low population countries as Switzerland, Sweden, Belgium, Netherlands, etc. It should come as no surprise, then, that there is almost no correlation between fleet size and per capita GDP.

I want now to express some thoughts concerning the variables that should be finally included in the model. It was seen that, even with two explanatory variables, we could get an adjusted R-squared of 36.779%, quite close to the value of 41.286%, which is the highest value we ever get for any subset of the 8 variables under consideration. This suggests that our model should be kept small, to 3 or 4 variables at most.[15] Given

[15]Cf. also the remarks in Section 1.2 concerning the possibility of heteroscedasticity.

No of Var.	Variables	Adjus. R-squ.
1	GDP	52.425
	Exports	25.303
2	GDP,Export growth	56.600
	GDP,Trade balance	54.270
3	GDP,Exports,Trade balance	61.690
4	GDP,Exports,Trade balance,Export growth	67.766
5	GDP,Exports,Trade balance,Export growth,Trade bal./Imports	66.646

Table 2.14: Best linear regressions for various numbers of explanatory variables for the alternative set of nations.

the fact that the variables to be retained should include GDP, exports, and export growth, and given the fact that the only other candidate variables are trade balance, per capita GDP growth, and GDP growth, I suggest to take as fourth variable GDP growth. This will give us a symmetric set of variables, in the sense that we will have two important economic indices (GDP, exports) and the growth rates of these two indices. Per capita GDP growth should be excluded because there is no reason to think that it should be important, given that per capita GDP is not. And trade balance should be excluded because its inclusion doesn't lead to any significant increase in the overall explanatory power of the model. I now propose to check these results by running the regressions again for the alternative set of nations listed in Table 2.2.

2.3.3 Alternative set of nations.

I ran the regressions for all subsets of the set of explanatory variables. The results are summarized in Table 2.14.

These results corroborate our previous conclusions on the importance of GDP, exports, and export growth. However, they don't seem to corroborate the assumption that the fourth variable to be included in the model should be GDP growth; they rather point towards inclusion of trade balance in the model. In view of this uncertainty, my final suggestion is that we limit the model to the three explanatory variables which are above suspicion, namely, GDP, exports, and export growth.[16] As said in the previous subsection, this limitation doesn't seem to result in decreased explanatory power (as measured by the adjusted R-squared coefficient) for the whole model. The difference between the values of the adjusted R-squared appearing in Table 2.14 between sets of 3 and 4 variables (61.690% versus 67.766%) should not be considered significant, in view of the fact that, generally, the values of the adjusted R-squared are higher in Table 2.14 than in the tables of the previous subsection, as a result of the significantly smaller sample size.

The conclusion of this chapter is that a linear regression model including as explanatory variables Gross Domestic Product, exports, and export growth, seems to have good explanatory power for merchant fleet size measured in deadweight tonnage of controlled fleet, and almost certainly such a model has about the best explanatory power that one can get by linear regression models based on ordinary economic indices.

[16]In fact, in Chapter 3 I will use only GDP and exports as explanatory variables, in order to keep the model manageable.

Chapter 3

Diachronic study.

This chapter consists of two sections. In the first section I run a set of linear regressions, each regression corresponding to a different year and having as dependent variable merchant fleet size (national flag fleet in deadweight tonnage) and as independent variable external trade (exports). In other words, I repeat, for various years, part of what I did in Section 2.2 for 1989. The purpose of running these regressions is to make an indirect check of the following hypothesis: although, in recent years, the flag fleets of several traditionally important maritime countries have shown a considerable decrease, the foreign flag fleets of these countries have shown a corresponding increase, so that the size of the total controlled fleets has remained relatively constant. It is not possible to check this hypothesis directly because data on the controlled fleets of various nations prior to 1989 don't exist. The way in which this hypothesis can be indirectly checked by running the regressions described above will be explained in the course of the first section.

In the second section of this chapter, I examine each nation individually. I run a multiple linear regression for each nation, the sample points of the regression corresponding to the various years. The purpose of running these regressions is twofold: first, to determine nation-specific linear relationships explaining merchant fleet size, relationships which could be used for prediction purposes; and second, to classify the various countries according to how good the regressions turn out to be (i.e., how high the coefficients of determination are), with the hope of drawing some inferences from this classification.

3.1 The controlled fleet constancy hypothesis.

In this section I give first data showing, quite explicitly and dramatically, that, over the last decade, there has been a very considerable decrease in the national flag fleets of several important maritime countries. Then I motivate the hypothesis that this decrease of national flag fleets has been matched by a corresponding increase in the foreign flag fleets of the same nations, so that the total controlled fleets of these nations have remained relatively constant. Finally, I show how one can indirectly check this hypothesis by running a series of linear regressions.

3.1.1 The decline of national flag fleets.

Take a look at Tables 3.1, 3.2, and 3.3. These tables give data on the national flag fleets of the 34 most important maritime countries for 1969 to 1989, with the exception of 1973, 1982, and 1983, for which data were not available. The data come from various issues of the *Review of Maritime Transport* (United Nations Conference on Trade and Development, New York: United Nations, 1969–1989). It is clear from these tables that, over the last decade, the flag fleets of several countries have dramatically decreased. Table 3.4 summarises the most important decreases. Several interesting remarks can be made by examining Table 3.4. First, the year at which the decline started varies among countries, but is always between 1979 and 1982 (with the single exception of Sweden, whose fleet started to decline in 1977). One can infer from this that the reasons for the decline were of a quite general impact, and were very probably related to the second oil crisis which occurred in 1978. Second, 11 of the 13 the nations whose fleets experienced a considerable decline belong to the set of the 15 most important maritime countries defined in Section 2.1. The only nations among those 15 whose fleets didn't experience a decline are the United States, Belgium, Australia, and Switzerland. The only nations not belonging to the 15 most important but whose fleets showed a large decrease were Greece and Spain. Third, the decrease was of an astonishing magnitude: 5 countries lost more than 68% of their flag fleet, and 5 more lost between 40% and 68% of their flag fleet. The conclusion is that the decline of the national flag fleets is an undeniable phenomenon of major proportions.

3.1.2 The constancy of controlled flag fleets.

Take now a look at Table 3.5. This table shows the total world fleet in deadweight tonnage from 1969 to 1989. The source is again the *Review of Maritime Transport* (various years). One can see that, starting from about 1978, the world fleet has remained approximately constant. In fact, the difference between the maximum of 688,803 kDWT (in 1981) and the minimum of 627,953 kDWT (in 1988) is a decrease of only 8.83%. Compared to the huge decreases of Table 3.4, this decrease is insignificant. Since the total world fleet has not changed, the following question presents itself: what has happened to the ships which, before the decline of flag fleets began, were registered under the flags of the nations in Table 3.4? A reasonable answer suggests itself: maybe the shipowners of the afflicted countries deliberately moved their ships from the flag of their own country to other flags.[1] If this were the case, then the total controlled fleet of each of the afflicted countries would have remained relatively constant. The hypothesis that the controlled fleets did in fact remain relatively constant is the object of this section, and I will now present an indirect way to check it.

If we had at our disposal the controlled fleets of the various nations for a series of years, then it would be very easy to check the hypothesis: we would simply have to look at the data. Unfortunately, such data do not exist. Indeed, according to the words of a United Nations specialist, the lack of such data "has always been a problem in maritime statistics on an international level"[2]. A special study was undertaken for the first time in 1989 in order to remedy this lack, and the results were the data I

[1]It can be seen from Tables 3.1, 3.2, and 3.3, that the flag fleets of several countries have considerably increased over the last decade. This has been the case, e.g., for Hong Kong, China, Korea, Brazil, Iran, Yugoslavia, Romania, Philippines, and Cyprus. Note also that the total flag fleets of "open-registry" countries have somewhat, but not very much, increased over the last decade.

[2]David Warner, United Nations Conference on Trade and Development (private communication).

Country	1969	1970	1971	1972	1974	1975
Greece	13136	16992	20871	24564	35975	37542
Japan	32593	40284	47476	55092	62176	64479
Un.States	17747	16111	14515	13693	15148	15606
Norway	31168	31390	35970	39246	42766	45597
USSR	13723	15255	16523	17198	19037	20107
Hong Kong	1122	997	843	676	375	594
Un.Kingdom	32499	38699	41639	44039	50345	53422
China	1088	1695	1453	2248	2691	4247
Rep. Korea	1128	1291	1460	1638	1859	2392
Fed.Germany	10267	12277	13674	13286	12467	13611
Italy	9727	10332	11696	11958	14086	15603
Brazil	1992	2417	2521	2723	3752	4293
India	3314	3781	3906	4155	5622	6281
Denmark	4795	5070	5460	6399	7120	7154
Iran	152	166	173	241	386	744
Singapore	312	551	771	1191	4396	6215
Cyprus	1187	1674	2186	2909	4967	4780
France	8089	9455	10560	11548	14462	18135
Yugoslavia	2043	2216	2266	2341	2650	2793
Spain	5751	4504	5521	6205	7389	8281
Turkey	752	841	871	921	1305	1365
Romania	495	511	539	626	871	1145
Belgium	1462	1527	1700	1711	1807	2055
Netherlands	7279	7415	7636	7211	8302	8631
Sweden	7151	7251	7514	8714	9886	12245
Poland	1965	2181	2422	2712	3119	4040
Kuwait	521	998	1057	1086	1132	1672
Philippines	1318	1296	1338	1312	1017	1211
Finland	1489	2066	2124	2308	2091	3008
Australia	963	1385	1451	1566	1577	1621
Canada	979	623	529	539	827	899
Switzerland	297	290	304	318	301	294
Pakistan	770	762	800	739	678	650
Argentina	1489	1621	1690	1799	1799	1891

Table 3.1: Data on flag fleet size (in kDWT) from 1969 to 1975 for the 34 most important maritime countries.

Country	1976	1977	1978	1979	1980	1981
Greece	41772	49323	57031	63310	67048	73514
Japan	68421	65870	64797	66315	67321	67497
Un.States	16484	17168	18909	21208	22198	23023
Norway	49278	49193	46389	39451	38885	38502
USSR	21931	23042	24222	25293	25895	26234
Hong Kong	607	896	1234	2240	2652	4069
Un.Kingdom	53806	51722	50459	45080	43814	41273
China	5265	6257	7598	9509	10217	11543
Rep. Korea	2650	3898	4681	6169	6836	8227
Fed.Germany	14884	15584	15700	13745	13332	12409
Italy	17461	17733	18698	19130	17951	17429
Brazil	4956	5336	6006	6657	7546	8531
India	8083	8746	9238	9375	9451	9732
Denmark	8196	8567	8939	8981	8703	7978
Iran	1070	1666	1805	1824	1933	1830
Singapore	9139	11352	12398	12924	12548	11547
Cyprus	4547	4015	3728	3362	2967	2677
France	19224	20052	21101	20825	20861	20112
Yugoslavia	2899	3445	3588	3662	3760	3880
Spain	9361	11712	13482	13943	13522	13801
Turkey	1486	1821	1970	2079	2134	2514
Romania	1414	1728	2044	2590	2656	2947
Belgium	2266	2438	2600	2723	2732	2948
Netherlands	9210	8055	7926	8405	8999	8600
Sweden	13350	12617	10868	7376	6626	6181
Poland	4609	4892	4934	5030	5101	4995
Kuwait	1868	3131	3819	4081	4219	3857
Philippines	1419	1640	1778	2380	2910	4034
Finland	3164	3415	3541	3845	3831	3795
Australia	1681	1910	2230	2404	2408	2648
Canada	759	853	1004	901	1042	1037
Switzerland	314	382	351	404	477	470
Pakistan	622	635	584	584	634	692
Argentina	1919	2262	2803	3372	3677	3308

Table 3.2: Data on flag fleet size (in kDWT) from 1976 to 1981 for the 34 most important maritime countries.

Country	1984	1985	1986	1987	1988	1989
Greece	62237	55356	51294	42776	39719	38465
Japan	64624	63451	59979	54669	48414	42357
Un.States	23304	23043	22959	23262	23334	22954
Norway	30605	25721	14203	9657	15235	26568
USSR	27928	28153	28146	28556	29199	29212
Hong Kong	9586	11333	13664	13471	12352	10337
Un.Kingdom	24140	21795	16872	11676	11113	10252
China	13940	15918	17424	18484	19360	20200
Rep. Korea	11211	11773	11562	11453	11524	12335
Fed.Germany	9519	9241	7745	5659	4994	4954
Italy	14939	14373	12407	12178	11867	11524
Brazil	9420	10040	10278	10438	10104	10063
India	10368	10761	10691	10891	9923	10207
Denmark	7973	7419	6805	6961	6333	6926
Iran	3411	3865	5064	7223	7939	8685
Singapore	11038	11187	10604	11925	11793	11888
Cyprus	11801	14299	18763	27323	32811	32699
France	15093	13713	9305	8407	6854	6653
Yugoslavia	4131	4180	4476	4940	5488	5815
Spain	12122	10820	9286	8387	7263	6461
Turkey	5174	6292	5713	5516	5441	5477
Romania	3932	4503	4843	4893	5357	5711
Belgium	3890	3854	3917	3654	3401	3282
Netherlands	6654	5949	5994	5123	4698	4557
Sweden	5196	4231	3037	2403	1927	1995
Poland	4304	4440	4694	4728	4667	4490
Kuwait	3880	3506	4121	3184	1011	2887
Philippines	5526	7571	11669	14828	15485	15468
Finland	3209	2854	1908	1401	811	838
Australia	3227	3094	3654	3701	3649	3707
Canada	1240	1133	1165	936	837	756
Switzerland	487	536	551	580	434	363
Pakistan	734	655	623	566	526	526
Argentina	3498	3335	3171	2853	2834	2764

Table 3.3: Data on flag fleet size (in kDWT) from 1984 to 1989 for the 34 most important maritime countries.

Country	Year decrease started	High fleet (kDWT)	1989 fleet (kDWT)	Decrease (%)
Sweden	1977	13350	1995	85.06
Un.Kingdom	1979	53806	10252	80.95
Finland	1981	3845	838	78.21
Fed.Germany	1979	15700	4954	68.45
France	1981	20861	6653	68.11
Spain	1980	13943	6461	53.66
Netherlands	1982	9210	4557	50.52
Greece	1982	73514	38465	47.68
Norway	1979	49278	26568	46.09
Italy	1980	19310	11524	40.32
Japan	1982	68421	42357	38.09
Canada	1982	1042	756	27.45
Denmark	1980	8981	6926	22.88

Table 3.4: The decrease of flag fleet for various important maritime countries.

Year	Fleet size
1969	288,328
1970	326,121
1971	365,175
1972	444,559
1974	486,931
1975	546,260
1976	601,243
1977	641,316
1978	662,799
1979	673,678
1980	682,768
1981	688,803
1984	674,480
1985	664,800
1986	639,083
1987	632,348
1988	627,953
1989	637,991

Table 3.5: Total world merchant fleet (in kDWT) for various years.

used in Chapter 2. But there are no data prior to 1989. It is, therefore, necessary to resort to indirect methods. I adopted the following approach. I ran a set of simple linear regressions, each regression corresponding to one year. Each regression had as dependent variable fleet size measured as flag fleet in deadweight tonnage, and as independent variable external trade measured as exports. The sample was the 34 most important maritime countries. In other words, I repeated, for a series of years, part of what I did in Section 2.2 for 1989. The data for exports are shown in Appendix B.

The results of the regressions, in terms of the coefficients of correlation, are shown in Table 3.6. It can be seen from that table that, over the period from about 1974 to 1986, the coefficient of correlation has remained relatively constant and approximately equal to 38%. But, over the last few years, this coefficient has fallen to about 28%. One can infer that national flag fleet has deteriorated as a measure of merchant fleet size. This deterioration is presumably related to the decline of flag fleets documented in the previous subsection (although it's not clear why the deterioration doesn't show up until 1986 while the decline of flag fleets started at latest in 1982). Now the important point is that, as shown in Section 2.2, the coefficient of correlation for the regression corresponding to the controlled fleet is 41.92%, which is about what the coefficient corresponding to the flag fleet was before it started to deteriorate. It is plausible to infer that, although the flag fleet was, but no longer is, a good measure of fleet size, the controlled fleet is still a good measure. Therefore, we have an indirect check of the hypothesis that the decline of national flag fleets has been compensated by a corresponding increase in foreign flag fleets. Although this check is indirect, I think it is of interest given the lack of data for controlled fleets prior to 1989.

The results of this section can be summarised as follows. In the past decade, several important maritime nations have experienced a very considerable decline of their flag fleets. It seems, however, that this decline has been compensated by a corresponding increase of the foreign flag portion of their controlled fleets, so that their total controlled fleets have remained relatively constant.

Year	Coeff.
1969	50.16
1970	47.75
1971	46.77
1972	42.59
1974	36.60
1975	37.51
1976	37.48
1977	37.96
1978	38.25
1979	34.97
1980	37.04
1981	37.49
1984	39.66
1985	40.87
1986	38.00
1987	32.08
1988	28.20

Table 3.6: Correlation coefficients for flag fleet size versus exports for the 34 most important maritime countries.

3.2 Time-series analysis.

In this section I examine individually selected nations (among the 34 most important). Since only time-series data for flag fleets exist, I resort to using flag fleet as a measure of fleet size. Given the results of Chapter 2, I chose as explanatory variables Gross Domestic Product and exports only. The time-series data for these two explanatory variables are shown in Appendix B. I first run a multiple linear regression for each selected country, and I give the regression coefficients. These coefficients are presumably useful for prediction purposes. Then I classify the examined nations into groups according to the adjusted coefficients of determination, and I attempt to explain the results of the classification.

3.2.1 Fleet size versus GDP and exports: multiple linear regression.

As can be seen from the tables in Appendix B and from Tables 3.1, 3.2, and 3.3 above, the time series we have at our disposal is not uninterrupted. For most countries, it consists of the following 14 years: 1969, 1970, 1972, 1975–1981, and 1984–1987.[3] For some countries 1984 is missing, and we are limited to a sample of 13 years. For yet other countries, like USSR, Iran, and Romania, several years are missing. Given these considerations, I finally examined 27 nations, for 24 of which I used a sample of 14 years and for 3 of which (Japan, India, and Cyprus), I used a sample of 13 years. For each of the 27 examined countries, I ran a multiple linear regression with flag fleet as the explained variable and GDP and exports as the explanatory variables. Table 3.7 gives the following results for each regression: the adjusted R-squared, the R-squared, the regression coefficients, and the probability of getting a value of the F-statistic higher than what we got, given that the model has no explanatory power at all. Note that I used units of billions of U.S. dollars for GDP and exports, and of thousands of deadweight tons for flag fleet, so that the unit for the regression

[3] I used 1973 GDP data for year 1972.

coefficients of the explanatory variables is kDWT/G$, and the unit for the intercept is kDWT.

I also performed the t-test on all regression coefficients, including the intercepts. Table 3.8 gives the results in terms of the probability of exceeding (in absolute value) the obtained value of the t-statistic, given that the coefficient in question is zero.

3.2.2 Interpreting the results.

The first thing which must be borne in mind is that our sample size is rather small: 14 years for most countries and 13 years for some. Moreover, the time series is not uninterrupted: there are gaps at 3 places. Finally, fleet size was measured by flag fleet, which is not exactly what we would have preferred, given the results of Section 2.2.[4] All this means that we shouldn't be too optimistic about getting very reliable results.

We can, however, draw several interesting conclusions from the results presented in Tables 3.7 and 3.8. We note first that there are enormous differences in the explanatory power of the regressions obtained, going from no explanatory power at all (adjusted R-squared 0), as is the case for France and Netherlands, to a very high explanatory power (adjusted R-squared greater than 90%), as is the case for Brazil, Korea, India, and Turkey. We can probably get some insight by ranking the 27 examined countries in decreasing order of the adjusted coefficient of determination, and this is done in Table 3.9.

It is easily seen from Table 3.9 that there are basically two categories of countries. The first category is composed of countries for which the multiple linear regression gave a very high adjusted coefficient of determination, above 80%. Twelve countries belong to this group, going from Brazil to Kuwait. The second category is composed of countries for which the multiple linear regression gave a low adjusted R-squared, below 50%. Again, twelve countries belong to this second category, going from Finland to Netherlands. There is also a small third group of three countries having intermediate

[4] Although the results of Section 3.1 suggest that the correlation between flag fleet and exports didn't start to deteriorate until 1987, which is only the end of our time series.

Country	R-squ. (%)	Adj.R2 (%)	Intercept	Coeff. of GDP	Coeff. of Exp.	F-prob. (%)
Greece	72.259	67.216	1672	* 2410	-7112	00.09
Japan	31.600	19.164	* 41643	-25	361	12.38
Un.States	85.822	83.244	* 13065	1	* 33	00.00
Norway	40.697	29.915	* 40588	387	* -1678	02.06
Hong Kong	88.597	86.523	-714	-195	* 533	01.38
Un.Kingdom	37.227	25.813	* 55364	-131	407	07.72
Rep. Korea	93.362	92.156	365	95	40	00.00
Fed.Germany	55.431	47.327	* 12105	* 27	* -113	01.17
Italy	76.700	72.464	* 12719	* -56	* 340	00.02
Brazil	97.396	96.922	1146	7	* 262	00.00
India	93.002	91.730	* 1727	-12	* 1214	00.00
Denmark	27.525	14.347	* 5820	73	-168	17.02
Cyprus	88.295	86.167	-338	*12957	*-38239	00.00
France	14.908	00.000	* 16532	-51	293	41.15
Yugoslavia	88.272	86.139	* 1847	7	* 188	00.00
Spain	36.732	25.228	* 6010	46	-165	08.16
Turkey	92.724	91.401	595	-3	* 613	00.00
Belgium	89.178	87.211	* 1768	* -36	* 87	00.01
Netherlands	14.745	00.000	* 8047	18	-52	33.16
Sweden	46.576	36.863	* 9462	159	-680	03.18
Kuwait	83.303	80.268	4232	* 1926	-59	00.00
Philippines	37.372	25.985	-691	-196	2639	07.63
Finland	56.617	48.720	* 2877	* -141	* 578	01.01
Australia	87.772	85.549	506	11	34	00.00
Canada	70.861	65.563	* 831	* -5	* 25	00.11
Switzerland	85.639	83.028	* 250	-2	15	00.00
Pakistan	33.850	21.822	* 670	7	* -88	10.30

Table 3.7: Results of the time-series regressions for 27 of the 34 most important maritime countries (*: coefficient significantly different from 0 at 5% level of significance, based on Table 3.8).

Country	Intercept	Coef. of GDP	Coef. of Exp.
Greece	0.8698	0.0275	0.2529
Japan	0.0002	0.4657	0.2573
Un.States	0.0000	0.4796	0.0000
Norway	0.0000	0.0565	0.0206
Hong Kong	0.5013	0.3037	0.0138
Un.Kingdom	0.0000	0.2902	0.4814
Rep. Korea	0.6363	0.0877	0.7612
Fed.Germany	0.0000	0.0302	0.0120
Italy	0.0000	0.0002	0.0000
Brazil	0.0620	0.0786	0.0000
India	0.0087	0.3735	0.0009
Denmark	0.0000	0.2973	0.4971
Cyprus	0.8298	0.0000	0.0029
France	0.0012	0.2349	0.2080
Yugoslavia	0.0000	0.3994	0.0000
Spain	0.0065	0.1775	0.4986
Turkey	0.2031	0.8260	0.0000
Belgium	0.0000	0.0026	0.0001
Netherlands	0.0000	0.4742	0.3316
Sweden	0.0023	0.1648	0.0728
Kuwait	0.2698	0.0045	0.4481
Philippines	0.8078	0.7788	0.5355
Finland	0.0000	0.0032	0.0030
Australia	0.0599	0.3742	0.6764
Canada	0.0000	0.0364	0.0126
Switzerland	0.0000	0.3604	0.0729
Pakistan	0.0000	0.2131	0.0054

Table 3.8: t-tests for the time-series regression coefficients for 27 of the 34 most important maritime countries.

	Country	Adj.R2
1	Brazil	96.922
2	Korea	92.156
3	India	91.730
4	Turkey	91.401
5	Belgium	87.211
6	Hong Kong	86.523
7	Cyprus	86.167
8	Yugoslavia	86.139
9	Australia	85.549
10	Un. States	83.244
11	Switzerland	83.028
12	Kuwait	80.268
13	Italy	72.464
14	Greece	67.216
15	Canada	65.563
16	Finland	48.720
17	Fed.Germany	47.327
18	Sweden	36.863
19	Norway	29.915
20	Philippines	25.985
21	Un.Kingdom	25.813
22	Spain	25.228
23	Pakistan	21.282
24	Japan	19.164
25	Denmark	14.347
26	France	00.000
27	Netherlands	00.000

Table 3.9: Ranking of 27 of the 34 most important maritime countries in decreasing order of the adjusted coefficient of determination.

adjusted coefficients of determination, from 65% to 72%, and these three countries are Canada, Greece, and Italy. Now a fundamental observation is that **none of the 13 countries afflicted by a decline of their flag fleet (shown in Table 3.4) belonged to the category of countries with high adjusted R-squared.** On the contrary, all the countries with low (or intermediate) adjusted coefficients of determination are among those afflicted by a decline of their flag fleet (with the exception of Pakistan and Philippines). In other words, there is almost a one-to-one correspondence between the countries having shown a marked decrease in their national flag fleets and the countries for which the multiple linear regression of the previous subsection has little or no explanatory power. Moreover, for the remaining countries (1 through 12 in Table 3.9) the linear regression seems to give good results and to have high explanatory power.

The above fundamental observations need to be explained. A plausible explanation is the following. The linear model having as explained variable *controlled* fleet and as explanatory variables GDP and exports has quite good explanatory (and, one can infer, predictive) power, but this is not the case if the explained variable is *flag* fleet. This hypothesis would explain why the regressions perform so well for the nations whose flag fleets have not been afflicted by a significant decrease in the last decade: presumably, for those nations, the flag fleet is a good measure of fleet size because it doesn't differ very much from controlled fleet. The hypothesis would also explain why the regressions concerning the nations whose flag fleets have been reduced perform so badly: presumably, for those nations, flag fleet is a bad measure of fleet size because it differs significantly from controlled fleet. It is clear that this hypothesis is in complete harmony with the results of Section 3.1, where we saw that, before the decline of national flag fleets began, flag fleet showed a high correlation with exports, so that one can infer that the correlation will continue to be good for the nations having experienced no flag fleet decline.

Now some remarks. Concerning first the group of nations with low adjusted coefficients of determination (countries 16 through 27 in Table 3.9), there are two among them, namely Pakistan and Philippines, which were not included in Table 3.4.

For the case of Pakistan, this might have been a mistake, because it can be seen from Table 3.3 that its flag fleet was reduced from 734 kDWT in 1984 to 526 kDWT in 1989, a decrease of 28.34%. But for the case of Philippines, one can see that its flag fleet has shown a considerable *increase*. I suggest that it is precisely this increase that deteriorates the quality of the regression for Philippines, because, as can be seen from the data in Appendix B, the GDP and the exports of Philippines have remained relatively constant over the recent years. Remaining in the context of the nations with low adjusted R-squared, it can be seen from Table 3.7 that none of them had a very low F-exceedance probability; this corroborates the hypothesis that, for these nations, the linear model has no explanatory power at all.

Concerning now the nations for which the linear model seems to perform quite well, it can be seen from Table 3.7 that, with the exception of Hong Kong, they all had an F-exceedance probability lower than 0.0001, so that the hypothesis that, for these countries, the linear model has no explanatory power at all must certainly be rejected. It can also be seen from Table 3.8 that, for some of these countries, some regression coefficients turn out not to be significant, so that a simpler regression model with no intercept or with only one of GDP and exports as explanatory variable should be included.

This section has presented concrete regression results which are presumably useful for predicting the future evolution of the fleet size of various countries. It has been argued, however, that these results have predictive power only for a group of nations, those that have not experienced a drastic decline of their national flag fleets. Prediction of the future evolution of the fleet size of the remaining nations will presumably require accumulation of time-series data on controlled fleets instead of flag fleets.

Chapter 4

Conclusions.

As stated in the Introduction (Chapter 1), the object of this thesis was the investigation, in the sense of both explanation and prediction, of the size of the merchant fleet of various important maritime countries. I decided at the outset to use as explanatory tool linear regression theory, and I gave some justification for taking the assumptions of the classical linear model to be satisfied. I chose as the set of nations to be examined the 35 most important maritime countries as classified by UNCTAD.

The first problem I faced was that it was unclear how fleet size, the explained variable, was to be measured. As flag fleet or controlled fleet? As number of vessels or deadweight tonnage? In order to answer this question, I ran, in Chapter 2 (Synchronic study), simple linear regressions for all possible definitions of fleet size against external trade. It was seen that, no matter whether external trade was defined as imports, exports, or their sum, measuring fleet size as controlled fleet always resulted in a greater coefficient of correlation than that corresponding to flag fleet, and measuring fleet size in terms of deadweight tonnage always resulted in a greater coefficient of correlation than that corresponding to measuring it in terms of the number of vessels. I concluded that **the best measure of fleet size is controlled fleet deadweight tonnage.**

The second problem I faced concerned the choice of the explanatory variables. A first obvious candidate was external trade, but it was also unclear how this was to be measured: as imports, exports, or their sum? The same simple linear regressions that enabled me to define fleet size gave also an answer to this question. It was seen that, no matter how fleet size was measured, all three possible definitions of external trade gave approximately the same coefficient of correlation with fleet size. I decided, therefore, to **measure external trade as exports.**

Then I wanted to enrich my model by including further dependent variables leading to an increase in explanatory power. I established a comprehensive list of ordinary economic indices consisting of: Gross Domestic Product, growth rate of GDP, per capita GDP, growth rate of per capita GDP, growth rate of exports, trade balance, and trade balance as a percent of imports. (I also considered population in Appendix A.) The multiple linear regression with these explanatory variables and with controlled fleet deadweight tonnage as the explained variable resulted in a considerable increase of explanatory power (as measured by the adjusted coefficient of determination) in comparison to the simple linear regression with exports as the single explanatory variable. It was clear that some further variables should be included in the model. By performing the t-tests on the coefficients of all variables, and by examining all possible subsets of explanatory variables, I arrived at the following conclusions. First, **Gross Domestic Product has by far the greatest explanatory power.** Second, **the only other uncontroversially important explanatory variables are exports and growth rate of exports.** Third, **per capita GDP, trade balance as a percent of imports, and population have no explanatory power at all.**

These were the results of the synchronic study (Chapter 2), which aimed almost exclusively at establishing an adequate model. The task of explaining past behaviour and of predicting future evolution was left to the diachronic study (Chapter 3). There I presented first data showing that, **over the last decade, all members of a set of 13 traditionally important maritime countries have experienced drastic declines of their flag fleets.** The fact that, over the same decade, the total world fleet has remained relatively constant, led to the hypothesis that there has been a "flagging-out" of the ships controlled by owners belonging to these countries, so that, despite the decrease of flag fleets, the controlled fleets have remained relatively constant. Lack of controlled fleet data prior to 1989 made a direct check of this hypothesis impossible, this is why I tried to check it indirectly. I ran a series of simple linear regressions with flag fleet as the explained variable and exports as the explanatory variable. I ran one such regression for every year for which there were available data. It was seen that the coefficients of correlation of these regressions were relatively constant in the past but have been significantly reduced in the last few years. I inferred that **flag fleet was, but no longer is, a good measure of fleet size.** (The fact that flag fleet is not a good measure of the fleet size was known from the results of the synchronic study. The new element here is that flag fleet *was* a good measure of fleet size in the past.) From the fact that the coefficient of correlation corresponding to controlled fleet has about the same value as the coefficient of correlation corresponding to flag fleet when flag fleet was a good measure of fleet size, I inferred that **the controlled fleet of the nations having experienced a marked decline of flag fleet has remained relatively constant**, validating thus indirectly what I had called the "controlled fleet constancy hypothesis". I emphasise that this check is only indirect, but, given the lack of data concerning controlled fleets, I think it is of interest.

Then came the most important part of the study, dealing with time-series analysis. The purpose of this analysis was mainly to find regression equations enabling one to predict the future evolution of the fleet sizes of selected individual nations (as well as to explain the past behaviour of these fleet sizes). I ran a multiple linear regression for almost each nation for which sufficient time-series data were available. The explained variable was flag fleet deadweight tonnage, and the explanatory variables were Gross Domestic Product and exports. The results of the regressions, in terms of both the adjusted coefficients of determination and the values of the F-statistic, showed that **two groups of nations should be distinguished. The first group consists of nations for which the linear regression model has quite good explanatory power** (i.e., adjusted coefficient of determination higher than 80%), and **the second group consists of nations for which the model has little to no explanatory power.** There is also a small third group of nations in between. Now the fundamental observation was that **there is roughly a one-to-one correspondance between the nations in the second group and the nations having experienced a drastic decline of flag fleet, and there is also roughly a one-to-one correspondence between the nations in the first group and the nations not having experienced a flag fleet decline.** I drew the following inferences from this fundamental observation. **The linear model having as explanatory variables Gross Domestic Product and exports performs quite well if the explained variable is controlled fleet, but performs quite poorly if the explained variable is flag fleet.** It follows that the regression equations corresponding to nations in the first group should be useful for prediction purposes, while the regression equations corresponding to nations in the second group should be relatively useless in this respect. But the basic result seems to be: **accumulation of time-series data for the controlled fleet should enable one to make predictions for all nations, including those of the second group.**

Given the data limitations, I think this thesis has been reasonably successful in achieving its objectives. The thesis has found the variables having explanatory power (mainly GDP and exports); it has produced, for some nations, regression equations presumably useful for prediction purposes; and it has explained why the regression model doesn't work for the remaining nations. It has also suggested a direction for future work, namely accumulation of time-series data on controlled fleets. It seems that the topic of the thesis, although far from being completely exhausted, looks now considerably more tractable.

Appendix A

The insignificance of population.

In the first section of this appendix I show that population should not be included as an explanatory variable in a linear regression model explaining merchant fleet size. I show this by a procedure similar to that used in Section 2.3 in order to find which other variables should be included in the model. In the second section of this appendix I show that per capita fleet size, considered as an explained variable, leads to very poor regressions. These results together show the insignificance of population relative to the problem which is the object of this thesis. This appendix can be considered an extension of the synchronic study (Chapter 2).

A.1 Population as an explanatory variable.

Data on the population of the 34 most important maritime countries are given in Table A.1.[1] The source is the *UNCTAD Handbook of international trade and development statistics, 1989*. Using these data as well as Tables 2.3 and 2.8, I ran the multiple linear regression of Section 2.3 but with one more explanatory variable, namely population. Then I performed the t-test on the regression coefficients of the 9 explanatory variables in the model. The results are given in Table A.2, which should be compared with Table 2.9.

Two remarks can be made at this point. First, the values of the t-statistic for the

[1] These data are for 1987.

Country	Contr.fleet (kDWT)	Population (thousands)	Fleet/Pop. (kDWT/M)
Greece	80,171	9,961	8048
Japan	72,805	121,991	597
Un.States	59,796	242,184	247
Norway	45,484	4,156	10944
USSR	28,440	283,899	100
Hong Kong	27,386	5,742	4769
Un.Kingdom	24,685	56,151	440
China	23,582	1,069,240	22
Rep. Korea	14,256	42,686	334
Fed.Germany	12,820	60,659	211
Italy	10,993	57,405	191
Brazil	10,304	141,486	73
India	10,256	786,220	13
Denmark	10,183	5,121	1988
Iran	8,632	47,283	183
Singapore	7,291	2,616	2787
Cyprus	7,265	683	10637
France	6,285	54,963	114
Yugoslavia	5,932	23,450	253
Spain	5,585	39,025	143
Turkey	5,473	51,432	106
Romania	5,442	23,336	233
Belgium	5,340	9,922	538
Netherlands	5,248	14,600	359
Sweden	4,660	8,333	559
Poland	4,205	37,717	111
Kuwait	3,960	1,979	2001
Philippines	3,489	57,088	61
Finland	3,352	4,921	681
Australia	2,956	16,102	184
Canada	2,886	25,954	111
Switzerland	2,735	6,380	429
Pakistan	2,705	105,119	26
Argentina	2,575	31,490	82

Table A.1: Data on controlled fleet size, population, and per capita contolled fleet size for the 34 most important maritime countries.

Explanatory variable	t-statistic	Prob. of higher $\|t\|$
Exports	-1.873	0.0750
Export growth	-2.211	0.0383
Trade balance	1.399	0.1765
Trade balance/Imports	0.339	0.7376
Gross Domestic Product	3.534	0.0020
Per capita GDP	-1.049	0.3059
GDP growth	-1.421	0.1699
Per capita GDP growth	1.625	0.1191
Population	-0.527	0.6040

Table A.2: t-tests on the coefficients of the multiple linear regression for 31 of the 34 most important maritime countries, including population as an explanatory variable.

variables already included in the model in Section 2.3 are very similar in Tables 2.9 and A.2, so that nothing new arises with respect to those variables and the conclusions of Chapter 2 remain unchallenged. Second, the t-value corresponding to population is such that population must clearly be rejected as an explanatory variable: its regression coefficient is not significantly different from zero.

In order to check this result, I also ran the above regression for all possible subsets of the set of the explanatory variables, as I did in Section 2.3. The results of Section 2.3 remained unchanged, and in no best regression was population included. For instance, the R-squared corresponding to the simple linear regression of fleet size versus population was only 1.31% (the regression coefficient was 0.01034 M$/kDWT).

Why is population insignificant? Wouldn't one expect nations with large populations to have large fleets? This is certainly the case for some countries, such as Japan, the United States, and China. But there are also several very low population countries with very large fleets, such as Greece, Norway, and Hong Kong. It is clear that, overall, fleet size and population are uncorrelated.

A.2 Population in the explained variable: per capita fleet size.

Table A.1 also gives data on the per capita fleet size of the 35 most important maritime countries. These data are repeated in Table A.3, where the countries are arranged by decreasing order of per capita controlled fleet size.

I ran the multiple linear regression with per capita fleet size as the explained variable and the 8 variables used in Section 2.3 as the explanatory variables. The value of the F statistic for the overall regression is 0.930, and the probability of getting a higher F value given that the model has no explanatory power at all is 0.5116. This probability is extremely high (cf. the corresponding probability of 0.0117 that we got by having total fleet size as explained variable). It seems, therefore, that the model has no explanatory value at all! This conclusion is validated by performing the t-test on the individual regression coefficients. The results are shown in Table A.4. *None* of the regression coefficients turns out to be significant, even at a **20%** significance level!! It is perfectly clear that per capita fleet size does not work as an explained variable.

Why is this so? Presumably for a combination of two facts: first, that the regression with total fleet size as the explained variable works quite well, and second, that ranking the countries with respect to their per capita fleets results in a significant rearrangement of their order. Countries with large fleets but also large population, such as China, India, Brazil, go to the end of the list, while countries with relatively small fleets but also small population, such as Cyprus, Kuwait, Finland, Sweden, go to the top.

The results of this appendix, together with the remarks in Section 2.3 concerning the role of per capita GDP, show that population, either in itself or in the form of per capita quantities, is irrelevant for the problem considered in this thesis.

	Country	Fleet/Pop. (kDWT/M)
1	Norway	10944
2	Cyprus	10637
3	Greece	8048
4	Hong Kong	4769
5	Singapore	2787
6	Kuwait	2001
7	Denmark	1988
8	Finland	681
9	Japan	597
10	Sweden	559
11	Belgium	538
12	Un.Kingdom	440
13	Switzerland	429
14	Netherlands	359
15	Rep.Korea	334
16	Yugoslavia	253
17	Un.States	247
18	Romania	233
19	Fed.Germany	211
20	Italy	191
21	Australia	184
22	Iran	183
23	Spain	143
24	France	114
25	Poland	111
26	Canada	111
27	Turkey	106
28	USSR	100
29	Argentina	82
30	Brazil	73
31	Philippines	61
32	Pakistan	26
33	China	22
34	India	13

Table A.3: Data on per capita contolled fleet size for the 34 most important maritime countries.

Explanatory variable	t-statistic	Prob. of higher $\|t\|$
Exports	-1.262	0.2203
Export growth	-0.482	0.6344
Trade balance	0.920	0.3673
Trade balance/Imports	-1.192	0.2459
Gross Domestic Product	0.762	0.4544
Per capita GDP	0.702	0.4899
GDP growth	-0.151	0.8812
Per capita GDP growth	0.090	0.9288

Table A.4: t-tests on the coefficients of the multiple linear regression for 31 of the 34 most important maritime countries, with per capita controlled fleet size as the explained variable.

Appendix B

Time-series data.

Tables B.1, B.2, and B.3 give data on the Gross Domestic Product of the 34 most important maritime countries for various years from 1969 to 1987. The sources are the *UNCTAD Handbook of international trade and development statistics* (various years) and the *Statistical Yearbook 1983/84* of the United Nations (Table 24, pp.100-104).

Tables B.4, B.5, and B.6 give data on the exports of the 34 most important maritime countries for various years form 1969 to 1988. The source is again the *UNCTAD Handbook of international trade and development statistics* (various years).

Country	1969	1970	1973	1975	1976
Greece	8395	9964	16290	20818	22040
Japan	166394	203567	413070	498777	555060
Un.States	947805	989513	1294900	1542180	1702020
Norway	9734	11183	18750	28449	31300
USSR	285710		506490		708170
Hong Kong	3100	3610	5998	9137	9322
Un.Kingdom	109748	123026	174800	235029	219180
China			216750		343090
Rep. Korea	7108	8755	12380	21146	25369
Fed.Germany	152843	184508	348170	417439	445910
Italy	82330	100613	138270	192047	170770
Brazil	31160	43614	77220	124277	144615
India	47670	53684	71000	88758	86152
Denmark	13989	15817	27350	37636	38530
Iran	9110	10183	25598	51924	66777
Singapore	1703	1896	4283	5640	5915
Cyprus	504	543	963	698	778
France	140050	140900	255060	338852	346760
Yugoslavia	12296	14553	22250	33280	37100
Spain	28739	36803	60230	104836	104620
Turkey	13016	12796	22036	35949	41050
Romania	16010		18539		31070
Belgium	22878	25618	45740	62893	68150
Netherlands	28271	33475	59670	86975	89520
Sweden	27850	33293	50100	72443	74220
Poland	34900		69860		98130
Kuwait	2352	2874	7165	12024	12144
Philippines	8138	6846	10330	15825	17795
Finland	9143	10891	17060	27532	28140
Australia	32708	37803	63900	95925	94120
Canada	68710	82810	118900	163964	194600
Switzerland	18454	20733	40870	54303	56290
Pakistan	16510	10602	8340	13338	14510
Argentina	19860	9000	31385	35750	47420

Table B.1: Data on Gross Domestic Product (in M$) from 1969 to 1974 for the 34 most important maritime countries.

Country	1977	1978	1979	1980	1981
Greece	26208	31607	38576	40147	36941
Japan	691466	962930	997604	1040456	1145126
Un.States	1878830	2145700	2388400	2606630	2934910
Norway	35589	40648	47131	57713	57086
USSR	780930				
Hong Kong	10737	16909	21582	27442	29526
Un.Kingdom	244457	321422	416091	533635	513166
China	372800				
Rep. Korea	34615	49623	64494	62279	68718
Fed.Germany	516150	639781	759574	813498	681827
Italy	196045	261888	325203	395520	353254
Brazil	166344	208301	234255	249725	275258
India	96633	119443	132486	162694	170340
Denmark	46017	56460	65937	66321	57250
Iran	77692	78462	89894	98081	106257
Singapore	6550	7806	9403	11343	13560
Cyprus	1042	1337	1749	2116	2047
France	380692	474425	573986	655305	572329
Yugoslavia	42550	54339	68199	69958	68930
Spain	115590	146485	195613	211781	187709
Turkey	47790	52499	69373	56918	57666
Romania	34260				
Belgium	79205	96829	111056	119493	98060
Netherlands	106406	137250	157507	169386	141423
Sweden	78259	91270	107839	124137	113182
Poland	109460				
Kuwait	12819	15520	24362	27581	24151
Philippines	20675	24120	29485	35249	38642
Finland	30171	34885	42865	51624	50627
Australia	100533	117944	130075	151145	172705
Canada	200149	207358	230624	259997	291515
Switzerland	60578	84829	95337	101629	94071
Pakistan	16970	19929	24001	28626	32607
Argentina	48948	65425	107962	154005	124436

Table B.2: Data on Gross Domestic Product (in M$) from 1977 to 1981 for the 34 most important maritime countries.

Country	1982	1983	1984	1985	1986	1987
Greece	38140	34815	33466	33407	39600	46191
Japan	1063104	1157456		1325203	1968911	2373050
Un.States	3045280	3275730	3634582	3959608	4191464	4463165
Norway	56131	55008	54719	58369	69587	20103
USSR						
Hong Kong	30634	28547	31996	34186	38439	46195
Un.Kingdom	483240	454662	425541	450066	551927	680736
China				265529	271884	293383
Rep. Korea	72329	76833	83284	86792	98307	121315
Fed.Germany	658393	654501	613356	622238	889356	1116256
Italy	347862	354884	348385	421984	605200	755883
Brazil	283076	209786	209398	226787	280192	302949
India	173005	193820		196904	228921	248991
Denmark	56005	56321	54633	58060	82455	101213
Iran	128661	159215				
Singapore	14852	16740		17475	17523	19895
Cyprus	2091	2096		2337	3103	3724
France	542754	516337	489434	522245	726950	881980
Yugoslavia	62827	46133	43356	44237	61706	62519
Spain	180870	158146	160926	163802	228118	289238
Turkey	53032	51148	49675	52783	58246	68010
Romania						
Belgium	86314	81944	78101	79589	111533	138888
Netherlands	138150	132600	123048	125426	175460	212874
Sweden	99901	91884	94824	100057	130803	161012
Poland				70457	73896	63904
Kuwait	20826	22045	21706	19734	16573	19536
Philippines	39881	34619	32836	32757	30742	34300
Finland	50866	49387	50662	54345	71076	89089
Australia	168165	168366	182136	155047	165545	196129
Canada	298989	324108	336746	348291	361460	411354
Switzerland	96542	97122	91100	92772	135227	170792
Pakistan	30875	31926	34051	30997	32091	34953
Argentina	56949	64829		65924	78801	80730

Table B.3: Data on Gross Domestic Product (in M$) from 1982 to 1987 for the 34 most important maritime countries.

Country	1969	1970	1971	1972	1973	1974
Greece	554	643	662	871	1454	2030
Japan	15990	19318	24019	28591	36930	55536
Un.States	37462	42590	43492	48968	70223	97144
Norway	2204	2457	2552	3252	4687	6274
USSR	11655	12800	13806	15361	21463	27405
Hong Kong	2178	2514	2871	3451	5051	5908
Un.Kingdom	17515	19347	22367	24345	30533	38639
China	2250	2307	2640	3210	4920	5950
Rep. Korea	623	835	1068	1624	3221	4460
Fed.Germany	29609	34849	39757	47116	68571	90590
Italy	11729	13206	15116	18548	22264	30253
Brazil	2311	2739	2904	3991	6199	7952
India	1835	2026	2034	2415	2940	3906
Denmark	3021	3356	3688	4511	6249	7718
Iran	2100	2150	3150	3800	5610	21120
Singapore	1549	1554	1755	2181	3610	5786
Cyprus	98	108	115	134	173	152
France	15021	17891	20595	26078	36041	45852
Yugoslavia	1474	1679	1836	2237	3024	3805
Spain	1900	2387	2938	3803	5161	7059
Turkey	537	588	677	885	1317	1532
Romania	1633	1851	2101	2599	3698	4874
Belgium	10089	11600	12730	16152	22453	28328
Netherlands	9965	11766	13942	16783	24054	32810
Sweden	5692	6792	7465	8767	12198	15937
Poland	3142	3548	3872	4932	6374	8315
Kuwait	1540	1600	2100	2300	2700	8900
Philippines	965	1119	1178	1159	1837	2725
Finland	1987	2306	2357	2947	3827	5527
Australia	4044	4621	5070	6302	9389	10785
Canada	13773	16119	17648	20352	25420	32912
Switzerland	4625	5128	5767	6828	9472	11788
Pakistan	692	734	679	698	958	1105
Argentina	1612	1773	1740	1941	3266	3931

Table B.4: Data on exports (in M$) from 1969 to 1974 for the 34 most important maritime countries.

Country	1975	1976	1977	1978	1979	1980	1981
Greece	2286	2543	2724	3375	3855	5142	4292
Japan	55840	67224	80493	97544	103045	129812	152016
Un.States	108050	113323	121293	143766	182025	220786	233739
Norway	7234	7917	8883	10877	13547	18545	18220
USSR	33316	37169	45159	52219	64761	76449	79003
Hong Kong	6019	8526	9626	11499	15155	19720	21737
Un.Kingdom	44114	46271	55867	67912	86422	110155	102820
China	7689	7960	8760	11120	15410	18270	23510
Rep. Korea	5081	7715	10046	12711	15055	17505	21254
Fed.Germany	90176	102032	118070	142454	171799	192930	176043
Italy	34995	36967	45327	56072	72243	77659	75187
Brazil	8670	10128	12054	12294	15244	20180	23082
India	4355	5526	6355	6650	7850	8378	7512
Denmark	8713	9113	10066	11885	14842	17190	16250
Iran	20212	23499	24259	22101	19975	14106	12505
Singapore	5376	6585	8241	10134	14233	19376	20967
Cyprus	152	258	318	344	456	533	556
France	52227	55816	63437	76502	97572	111114	101371
Yugoslavia	4072	4557	5256	5668	6605	10770	10929
Spain	7669	8727	10229	13115	18203	20721	20337
Turkey	1401	1960	1753	2288	2261	2911	4703
Romania	5341	6138	6979	8077	9724	11401	12610
Belgium	28804	32888	37542	44961	56705	64664	55705
Netherlands	35099	40167	43702	50151	63697	73952	68732
Sweden	17382	18440	19093	21794	27605	30969	28664
Poland	10282	11017	12265	14114	16249	16997	13249
Kuwait	9184	9848	9768	10443	18722	19671	16298
Philippines	2294	2574	3151	3425	4601	5788	5722
Finland	5503	6342	7665	8572	11175	14153	14015
Australia	11945	12868	13351	14415	18667	22031	21767
Canada	32682	38127	41876	45567	56053	65123	70018
Switzerland	12957	14845	17682	23561	26507	29634	27042
Pakistan	1035	1163	1174	1475	2056	2588	2880
Argentina	2961	3916	5652	6400	7810	8021	9143

Table B.5: Data on exports (in M$) from 1975 to 1981 for the 34 most important maritime countries.

Country	1982	1983	1984	1985	1986	1987	1988
Greece	4297	4412	4811	4542	5650	6535	5307
Japan	138911	146668	170107	175683	209153	229224	264959
Un.States	212277	200538	217888	213146	227158	254122	322224
Norway	17595	17628	18892	19991	18097	21491	22511
USSR	86912	91343	91652	87281	97247	107874	110559
Hong Kong	20985	21951	28317	30039	35439	48473	63163
Un.Kingdom	97095	91939	94502	101332	106981	131210	145151
China	21913	22150	24871	27343	31064	39542	47650
Rep. Korea	21853	24445	29245	30283	34714	47281	60696
Fed.Germany	176428	169425	169784	184009	243303	294045	323277
Italy	73479	72681	73303	78957	97835	124005	127114
Brazil	20213	21899	27005	25639	22376	26225	33787
India	8807	8713	9874	8750	9187	11596	13248
Denmark	15595	16047	15959	16454	21201	25615	27140
Iran	19414	20247	13223	12378	8322	11000	10600
Singapore	20788	21833	24108	22813	22495	28686	39305
Cyprus	555	494	575	476	506	621	709
France	92629	91231	93215	97633	119340	143391	167792
Yugoslavia	10241	9913	10254	10642	10298	11425	12597
Spain	20283	19794	23587	25112	27174	34160	40067
Turkey	5685	5728	7134	7957	7458	10189	11608
Romania	10123	10163	10720	10988	11740	12180	13000
Belgium	52364	51939	51779	53760	68876	83109	92787
Netherlands	66288	65678	65881	68282	80565	92876	103561
Sweden	26817	27466	29378	30490	37230	44834	49888
Poland	11172	11572	11750	11488	12074	12205	13956
Kuwait	10959	11574	12275	10479	7221	8468	7161
Philippines	5021	5005	5322	4544	4842	5565	7035
Finland	13132	12519	13505	13617	16340	19560	22151
Australia	22038	20687	23998	22883	22496	26455	32734
Canada	68496	73514	86729	87479	86725	94402	112863
Switzerland	26024	25595	25863	27451	37674	45742	50861
Pakistan	2395	3074	2614	2719	3306	4090	4497
Argentina	7626	7835	8107	8396	6852	6360	9135

Table B.6: Data on exports (in M$) from 1981 to 1988 for the 34 most important maritime countries.

Bibliography

[1] Damodar Gujarati. *Basic Econometrics.* McGraw-Hill, 1978.

[2] Bernard W. Lindgren. *Statistical Theory.* Macmillan, 1976.

[3] Henry S. Marcus, Daniel H. Stahl, and Christopher N. Nikoi. *U.S.-owned merchant fleet: The last wake-up call?* Massachusetts Institute of Technology, Cambridge, MA, 1991.

[4] United Nations. *Statistical Yearbook 1983/84.* New York, 1986.

[5] United Nations Conference on Trade and Development. *Handbook of international trade and development statistics.* United Nations, New York (various years).

[6] United Nations Conference on Trade and Development. *Review of Maritime Transport.* United Nations, New York (various years).

[7] United Nations Conference on Trade and Development. *UNCTAD Statistical Pocket Book.* United Nations, New York, 1989.