EXPORT DEMAND AND SUPPLY ELASTICITIES FOR SELECTED INDUSTRIAL COUNTRIES 1970 - 1983

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ABSTRACT

This paper attempts to provide estimates of demand and supply elasticities of exports of four major industrial countries, viz., the USA, the UK, Federal Republic of Germany and Japan, using simultaneous equations methods (TSLS and FIML) and employing quarterly data for the period 1970 (I)-1983 (IV). Our results of long-run demand price elasticities are found to be less than unity and are generally lower than those obtained by other researchers. Second, our estimates of income elasticity of demand for exports show lesser inter-country variation than those of other investigators, a finding which is in line with Balassa's contention against a wider range of estimates for different countries. Finally, we find that export supply is highly sensitive to capacity growth and that the degree of sensitivity correlates strongly positively with 'openness' of a country and weakly negatively with its size as measured by the GDP. This result implies that for a given capacity, expansion is likely to result in greater export expansion in economies that are small and already very open.

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1. INTRODUCTION

The literature on the estimation of demand and supply relationships in foreign trade produced during the last three decades emphasises the estimation of demand equations. Indeed, attempts to estimate supply equations have been so few that Goldstein and Khan (1985), in their recent survey of empirical literature on foreign-trade flows, open the subsection on supply elasticities with the remark, "Despite over thirty years of econometric work on trade equations, it does not take a very large table to present a reasonably comprehensive list of existing estimates of the price elasticity of supply of exports."[1] A similar sentiment is expressed by Haynes and Stone (1983) who begin their paper with the comment, "Supply behaviour in international trade has been notoriously difficult to capture empirically."

An even more disconcerting fact about the literature on the estimation of foreign trade relationships concerns the infrequency with which investigators have estimated both demand and supply equations. In the case of import equations, the practice of ignoring the supply equation can be justified on the ground that in most cases an individual country faces a perfectly elastic supply of its imports. A similar argument cannot be made, however, in the case of exports. Yet only a small number of studies have attempted to estimate both the demand and supply equations for exports. For example, the Goldstein and Khan (1985) survey mentions only four major studies in this category; Magee (1970), Goldstein and Khan (1978), Gylfason (1978), and Dunlevy (1980).[2]

The purpose of this paper is to present estimates of long-run elasticities of demand and supply for total exports for four major industrial countries, namely, the United States, the United Kingdom, Japan and Federal Republic of Germany. We employ a simultaneous equations approach and use the more recent quarterly-data covering the period 1970 to 1983 to estimate these elasticities. As the existing list of such estimates is relatively short, our paper should constitute a welcome addition to the literature. By comparing our estimates with those of others, we can get some idea of whether the export demand and supply elasticities have changed significantly over time.

Most studies employing the simultaneous equations framework have relied on the single-equation method of Two Stage Least Squares (TSLS). A notable exception in this regard is Goldstein and Khan (1978) which uses the systems method of Full Information Maximum Likelihood (FIML). We experimented with both the methods and found that after correcting for autocorrelation, the FIML method frequently yielded coefficients with wrong signs.[3] Therefore, like the majority of investigators in the area, we chose to rely on the TSLS estimator.

In using the TSLS procedure, an obvious question concerns the normalisation of equations. Haynes and Stone (1983), who estimated supply (but not demand) equations for exports and imports for USA and UK using this procedure, found that normalisation with respect to price yields better fits. In our computational work, we experimented with both normalisations and found the fits to be better when equations are normalised

with respect to quantity rather than price. We are not certain what significance should be attached to this finding but since the issue of normalisation has been raised in the literature, we find it useful to at least mention it.

A final question concerns the choice of a proxy variable to represent the production capacity in the export supply equation. Two variables that have been used in the literature for this purpose are trend income e.g., Goldstein and Khan (1978) and Haynes and Stone (1983) and trend production e.g., Dunlevy (1980) . Once again, we experimented with both variables and found that the latter performed better. Therefore, in the equations reported in the paper, the production capacity is proxied by trend production.

The paper is organised as follows. In Section 2, we briefly describe the model. In Section 3, we report our results and compare them with those obtained by other researchers. Finally, in Section 4 we summarise our conclusions. The appendix provides details regarding data sources and definitions of variables.

2. THE MODEL

The model we propose to estimate is familiar in the literature and can be found in Goldstein and Khan (1978, 1985). It is assumed that a country's exports are imperfect substitutes for the exports of other countries so that the quantity demanded of its exports varies inversely with its export price relative to the rest of the world's export price. Additionally, the export demand depends positively on the world income. Formally, denoting the quantity demanded by X^d, the country's

export price by PX, the world price of exports by PXW, and the world income by YW, we have

$$\ln X^d = a_0 + a_1 \ln(PX/PXW) + a_2 \ln(YW) \qquad (1)$$

The supply of exports by the country is hypothesised to depend positively on its export price relative to the domestic price and on the production capacity. Denoting the export supply by X^s, the domestic price by P and the production capacity by MFGT, we have

$$\ln X^s = b_0 + b_1 \ln(PX/P) + b_2 \ln(MFGT) \qquad (2)$$

Finally, equilibrium requires

$$X^s = X^d = X \qquad (3)$$

The hypothesised signs of the coefficients are, $a_1 < 0$ and $b_1, b_2, a_2 > 0$.

As usual, we assume that X and PX are endogenous while the other variables are exogeneous to the system. Equations (1) and (2) are estimated in the form shown by the TSLS method for four industrial countries, namely, USA, UK, Japan, and Federal Republic of Germany using quarterly data starting from the first quarter of 1970 and ending with the last quarter of 1983. The endogenous variables X and PX, respectively, are measured by the quantity and unit value indices of exports of the country in question, PXW is proxied by the unit value index of exports of all industrial countries, YW is a weighted average of real incomes of major industrial countries relevant to a given exporting country and MFGT is the logarithmic trend in production of the exporting country. The appendix at the end of the paper describes in detail the data sources and the manner in which some of our variables were constructed.

3. RESULTS

Table 1 shows the TSLS estimates of export demand and export supply equations for the four industrial countries considered in this study together with the values of important statistics, namely, $\bar{R}^2$, the F-value and the Durbin-Watson statistic. As can be seen in this table, the estimated price elasticities carry the expected negative sign in export demand equations and the expected positive sign in export supply equations for all four countries. They are all found to be statistically significant at the 5 per cent level except for demand price in the case of UK and supply price in the case of Japan and Federal Republic of Germany. Estimates of income and capacity growth (activity) elasticities have correct signs and are significant at the 5 per cent level in all four cases. Judging from the value of $\bar{R}^2$ which ranges between 0.75 and 0.95, the data used to estimate the equations may be regarded as exhibiting an acceptable "goodness of fit" for all four countries. It may be noted that our estimates have been obtained after adjusting for autocorrelation (see the DW values in Table 1).

As noted in the introduction, we also estimated the model represented by equations (1)-(3) by the FIML method using the same set of quarterly data for the four countries. Unfortunately, the estimated equations exhibited the problem of autocorrelation. Attempts to correct for autocorrelation resulted in wrong signs for many of the coefficients. As the FIML estimates of elasticities (unadjusted for autocorrelation) had proper signs and were statistically significant, we have included them in Table 2 along with our own TSLS results

and those of a few other authors for purposes of comparison. Note that the estimates of Goldstein and Khan in Table 2 are based on the FIML method, those of Balassa on the constant market shares approach, and all the rest on the TSLS method. For clarity of presentation, we have separated the demand and supply price elasticities shown in Table 2 from the income and capacity growth elasticities shown in Tables 3 and 4, respectively.

Let us first consider the price elasticities of export demand for the four countries. It is evident from Table 2 that these elasticities vary across countries as well as across studies reported here. Considering the fact that the various studies are based on different methodologies, specifications, and time periods, this fact is hardly surprising. Comparing our TSLS estimates with those of Dunlevy (1980) who estimated a similar specification as ours for the period 1957-75 or with those of Amano et al. (1981) who estimated the demand equation using data for the period 1971-77, we see that export demand has continued to be price inelastic over time for all four countries. The elasticities estimated by us are somewhat larger than those of Dunlevy and Amano et al. Turning to the FIML method, we find that our estimates are substantially smaller than those of Goldstein and Khan and much closer to the various TSLS estimates than those of the latter.

Our TSLS estimates of export supply elasticity are comparable with those of the other studies shown in Table 2. As in most other cases, our estimate is the highest for USA. What is different, however, is that this estimate is not as

large as the corresponding estimates reported by some other authors. For example, Goldstein and Khan (1985) observe in their survey that "excluding the United States, the supply-price elasticity for the total exports of a representative industrial country appears to be in the range of one to four. The supply elasticity for US exports is probably considerably higher than that, perhaps even reaching ten to twelve." Our estimate for USA is obviously in contradiction with this statement and lies well within the one-to-four range mentioned by Goldstein and Khan for other industrial countries. It is of interest to note that as in the case of the demand equation, our FIML estimates of export-supply elasticity are much smaller than those of Goldstein and Khan and are much closer to the TSLS estimates obtained by us and other investigators. One difference between the equations estimated by Goldstein and Khan and us is that we assume supply to be homogeneous of degree zero in PX and P while the latter do not do so.

Table 3 compares our estimates of the income elasticity of demand for exports with the corresponding estimates of other investigators. Compared to the Goldstein and Khan estimates, our estimates show surprisingly little variance across countries. In particular, the former find the elasticity of demand for US exports to be 1.01 while that for Japan to be as high as 4.22. By contrast, our TSLS estimates are 1.43 and 1.65, respectively, for the two countries. The corresponding estimate for Germany is 1.78 and that for UK is 1.67. Our FIML estimates, while generally slightly lower than the TSLS estimates, reinforce strongly the story regarding a lack of variation in the income elasticity of demand

across countries. Our estimates lend some support to Balassa's contention that Goldstein and Khan's estimate of income elasticity of demand was biased upward for Japan and downward for USA. In conformity with Balassa's observation, the use of proper capacity variable such as trend in industrial production instead of trend in real income does seem to result in narrower inter-country differences in the estimates of income elasticity of export demand. Balassa's argument is that compared with trend in industrial production, trend in real income overstates capacity growth in USA and understates it in Japan which, in turn, leads to higher estimates for income elasticity for the former and lower estimates for the latter.[4]

Table 4 compares our estimates of capacity growth elasticity with those of other investigators. Our estimates (both TSLS and FIML) are positive and significant in all four cases. The estimate is the highest for Germany (4.18) and lowest for USA (1.12). Our estimates suggest that, except in the case of USA, exports are highly sensitive to capacity growth.

Finally, Table 5 presents the capacity elasticities of export supply for nine industrial countries and correlates them with country size and the degree of openness as measured by the share of exports in GDP. These estimates were obtained by estimating equations postulated in the previous section.[5] According to Table 5, the capacity elasticity increases with the degree of openness and falls with the GDP although the former relationship is much stronger than the latter. More

precisely, Spearman's rank correlation coefficient between the capacity elasticity and openness turns out to be 0.8 for these nine countries. The corresponding correlation of the elasticity with country size is -0.5.

4. CONCLUSIONS

In this paper, we have provided estimates of export demand and supply elasticities for four major industrial countries using both the TSLS and FIML methods. The four countries are USA, UK, West Germany and Japan and we have used quarterly data for the period 1970I-1983IV. Unlike most of the other investigators in the area, we have estimated both the demand and supply equations and employed a simultaneous equations framework.

The findings of this paper may be summarised as follows. First, our estimates of the long-run elasticity of demand for exports are generally lower than those obtained by Goldstein and Khan but higher than the ones obtained by other investigators. In all four cases, our estimates are below unity. Second, our estimates of income elasticity of demand for exports show less variation than those of other investigators. All of our TSLS estimates of this elasticity lie in the range 1.4 to 1.8. This finding is in line with Balassa's contention against a wider range of inter-country differences in the estimates obtained by Goldstein and Khan. Finally, we find that export supply is highly sensitive to capacity growth. The

degree of sensitivity of exports to capacity growth correlates strongly positively with openness as measured by the ratio of exports to the GDP and weakly negatively with size as measured by the GDP. This result implies that for a given capacity, expansion is likely to result in greater export expansion in economies that are small and already very open!

In conclusion, it is perhaps worth pointing out that we have found the export price variable to perform generally poorly in our efforts to estimate the demand and supply equations for exports. Indeed, for most of the countries included in Table 5, but not in Tables 1-4, the results of estimation with respect to price variables after correcting for autocorrelation were very mixed. This fact has at least two possible interpretations. First, as is often alleged, the unit-value index is a very poor measure of variations in the aggregate export price. Second, at the aggregate level, the demand for and supply of exports is largely determined by non-price variables such as income and production capacity.

APPENDIX

Data Definitions

All data are quarterly, seasonally adjusted, where necessary and relate to the period 1970 I through 1983 IV. The base year is 1980 throughout. The variables used in the model are defined as follows:

X - index of volume of exports

PX - index of unit value of exports

P - index of consumer prices (wholesale price index for USA and Japan)

PXW - index of export prices of all industrial countries

MFGT - logarithmic trend in the index of industrial production

YW - "world" real income expressed as an index. YW for the jth country denoted YW_j is calculated as follows:

$$YW_j = \sum_i a_{ji} Y_i \qquad i = 1,2,.....12.$$

$$\sum_i a_{ji} = 1$$

where a_{ji} is the weight of the i-th market in j-th country's exports to 12 industrial countries and Y_i measures real income in the i-th country. The twelve countries are USA, UK, Austria, France, Federal Republic of Germany, Italy, Sweden, Switzerland, Canada, Japan, Finland and Australia.

Formally, as described in Houthakker and Magee (1969), $a_{ji} = VX_{ji}/VX_j$ $(i,j = 1, \ldots 12)$, where VX_{ji} represents average exports (in value terms) from country j to i over N priods. As our period of investigation ranges from 1970 I to 1983IV, we have N = 56. In precise terms, we have $VX_{ji} = \frac{1}{N}\sum_{t-1}^{N} VX_{jit}$ and $VX_j = \sum_i VX_{ji}$.

Y_i has been derived as follows. The data on the gross domestic product at factor cost at 1980 prices are available in domestic currency units on a quarterly basis for all the twelve industrial countries mentioned earlier.

Unlike Goldstein and Khan (1978), who derived quarterly income series from annual data, we employed the original quarterly series as reported in IFS to represent movements in real income over time. These series were converted from domestic currency units to a common currency, namely, the Special Drawing Rights (SDRs) by using appropriate exchange rates.

Data sources

The data on VX_{jit} were taken from the computer tapes, Direction of Trade Statistics, Annual (DOTA) and those on all other variables are from International Financial Statistics, Quarterly (IFSQ), International Monetary Fund.

NOTES

1. As regards import-supply elasticities, Goldstein and Khan mention only two studies in a footnote. These studies are by Magee (1970) and Gylfason (1978).

2. Mention may also be made of a short note by Browne (1982). It may be noted that some studies which estimate only the demand-for-exports equation do correct for the simultaneity bias. For example, see Basevi (1973) and Khan (1974).

3. It is perhaps worth noting in this context that the FIML estimates can be highly sensitive to small changes in specification and data.

4. Over the relevant period, GNP grew at a much lower rate than value added in the production of tradable goods in Japan while the opposite holds for USA. As trend in industrial production which includes mostly tradables is likely to proxy export capacity better than trend in GNP which includes both tradables and non-tradables, the latter will overstate capacity growth in USA and understate it in Japan.

5. For countries other than those included in Tables 1.4, the price elasticity was generally either of the wrong sign or insignificant. The general failure of the price variable to perform well in our supply equations suggests that either the unit-value index is a hopelessly poor proxy for the export price or the export performance is determined by non-price variables.

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TABLE 1

Estimated Equations of Export Demand and Export Supply

Date Period: 1970I-1983IV

Country	Estimated Equations and Statistics (Adjusted for auto-correlation)

United States

i. Export Demand :

$$\ln X^d = \underset{(-1.911)}{-2.04} \underset{(-2.518)}{-0.96} * \ln\left(\frac{PX}{PXW}\right) + \underset{(6.003)*}{1.43} \ln YW$$

$$\bar{R}^2 = 0.874 \quad ; F(2,52) = 188.08; \ D.W = 2.36$$

ii. Export Supply :

$$\ln X^s = \underset{(=.449)}{-0.69} + \underset{(2.459)*}{1.27} \ln\left(\frac{PX}{P}\right) + \underset{(3.293)*}{1.12} MFGT$$

$$\bar{R}^2 = 0.876 \quad ; F(2,52) = 191.50; \ D.W. = 2.43$$

United Kingdom

i. Export Demand :

$$\ln X^d = \underset{(-1.004)}{-3.14} \underset{(-.0.296)}{-0.09} \ln\left(\frac{PX}{PXW}\right) + \underset{(2.439)*}{1.67} \ln YW$$

$$\bar{R}^2 = 0.760 \quad ; F(2.52) = 82.34; \ D.W. = 2.51$$

ii. Export Supply :

$$\ln X^s = \underset{(-8.000)}{-12.42} + \underset{(3.627)*}{1.05} \ln\left(\frac{PX}{P}\right) + \underset{(10.911)*}{3.69} MFGT$$

$$\bar{R}^2 = 0.858 \quad ; F(2,52) = 164.52; \ D.W. = 2.01$$

Japan

i. Export Demand : $\ln X^d = -3.05 \underset{(-2.072)*}{-0.87} \underset{(-4.926)*}{\ln\left(\frac{PX}{PXW}\right)} + \underset{(5.237)*}{1.65 \ln YW}$

$\bar{R}^2 = 0.930$; $F(2,52) = 358.91$; D.W. = 2.36

ii. Export Supply : $\ln X^s = \underset{(-3.413)*}{-9.08} + \underset{(1.179)}{1.01 \ln\left(\frac{PX}{P}\right)} + \underset{(5.180)*}{2.98 MFGT}$

$\bar{R}^2 = 0.962$; $F(2,52) = 682.76$; D.W. = 2.27

Federal Republic of Germany

i. Export Demand : $\ln X^d = \underset{(-1.41)}{-3.53} \underset{(-3.963)*}{- 0.59 \ln \frac{PX}{PXW}} + \underset{(3.284)*}{1.78 \ln YW}$

$\bar{R}^2 = 0.89$; $F(2,52) = 203.63$; D.W. =2.36

ii. Export Supply : $\ln X^s = \underset{(-8.182)*}{-14.47} + \underset{(.65)}{0.67 \ln \frac{PX}{P}} + \underset{(10.73)*}{4.18 MFGT}$

$\bar{R}^2 = 0.92$; $F(2,52) = 304.78$; D.W. =2.17

Note: Numbers in parentheses are t-values and '*' mark denotes significance at the 5% level.

TABLE 2

Long-run Price Elasticities of Export Demand and Supply Estimated by Different Authors

Country	G.K. (FIML)	Ours (FIML)	Dunlevy (2SLS)	Amano et.al (2SLS)	Gylfason (2SLS)	Ours (2SLS)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
US						
Export Demand	-2.78	-0.58	-0.56	-0.32	-0.62	-0.96
Export Supply	+6.60	+0.85	+1.09	N.A.	+2.40	+1.27
UK						
Export Demand	-1.32	-0.35	-0.48	-0.08	-0.32	-0.09
Export Supply	+1.40	+0.83	+1.45	N.A.	+0.80	+1.05
Japan						
Export Demand	+2.47	-1.18	N.A.	-0.81	-2.13	-0.87
Export Supply	+0.00	-1.00	N.A.	N.A.	+1.70	+1.01
Federal Republic of Germany						
Export Demand	-0.83	-0.65	N.A.	-0.29	-0.38	-0.59
Export Supply	+4.60	+1.01	N.A.	N.A.	+0.80	+0.67

Note: The results obtained by the researchers shown above relate to different time periods and estimating techniques, viz., GK's data period is 1955-70, Dunlevy 1957-75, Amano et al. 1971-77 and Balassa 1953-71. While our results refer to the latest period 1970-1983. Similarly, while GK employed FIML techniques of estimation, all others used 2SLS procedures to generate the elasticities; however Balassa followed constant-market-share approach.

TABLE 3

Income Elasticities of Demand Estimated by Different Authors

Country	G.K. (FIML)	Ours (FIML)	Dunlevy (2SLS)	Balassa (C.M.S.)	Ours (2SLS)
(1)	(2)	(3)	(4)	(5)	(6)
US	1.01	1.48	0.78	2.02	1.43
UK	0.92	2.71	0.59	2.20	1.67
Japan	4.22	1.50	N.A.	2.00	1.65
Federal Republic of Germany	1.80	1.89	N.A.	2.27	1.78

Note: As in Table 2.

TABLE 4

Capacity Growth Elasticities Estimated by Different Authors

Country	G.K. (FIML)	Ours (FIML)	Dunlevy (2SLS)	Balassa (C.M.S.)	Ours (2SLS)
(1)	(2)	(3)	(4)	(5)	(6)
US	2.41	1.79	1.27	N.A.	1.12
UK	2.09	3.88	1.64	N.A.	3.69
Japan	2.63	1.84	N.A.	N.A.	2.98
Federal Republic of Germany	5.50	4.19	N.A.	N.A.	4.18

Note: As in Table 2.

TABLE 5

Ranking of Industrial Countries According to Capacity Growth Elasticity of Export Supply, Size and Degree of Openness during the Period 1970-1983

Exporting country	Capacity growth elasticity of export supply (2SLS estimates)	Rank	Size of country[2/] (Real GNP for 1970-83) Billion US $	Rank	Degree[2/] openness (Export share in GNP, averaged for 1970-83) (%)	Rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)
US	1.19	9	2488.8	1	7.9	9
UK	3.69	4	452.8	5	26.0	4
Japan	2.98	5	913.1	2	13.5	8
Germany	4.18	3	567.0	3	27.0	3
France	2.80	7	496.0	4	19.3	7
Italy	2.89	6	378.1	6	21.4	6
Sweden	7.84	2	101.3	8	28.7	2
Switzerland	15.61	1	71.0	9	33.9	1
Canada	1.71	8	242.2	7	24.7	5

Notes: 1/ All 2SLS estimates of capacity growth elasticity are statistically significant at the 5% level and have been obtained by estimating the respective export supply equations as hypothesised in section 1 using quarterly data for the period 1970 I-1983IV.

2/ Data on real GNP (GNP at 1980 prices), export value, GDP are taken from International Financial Statistics originally in domestic currency units; they are subsequently converted to US dollars using annual average exchange rates available from the same source.

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