

# Demand and Supply Functions for Irish Exports of Manufactures.\*

THOMAS O'CONNELL  
*Central Bank of Ireland*

## I INTRODUCTION

In this paper, we specify and estimate some simple quarterly econometric models of Irish manufactured exports looking at the determinants of both the demand for, and the supply of, manufactured exports. The standard definition of manufactured exports is taken, i.e., SITC (Standard International Trade Classification) 5–8 inclusive; the data period used for estimation is 1964 to 1974 (with extra observations, where necessary, for lags).

The first part of the paper presents the results of alternative single equation models of manufactured exports, noting the implicit assumptions of such models. The second section of the paper applies a simple two-equation model to Irish data. The latter involves the specification of demand and supply functions, and can be used assuming equilibrium or, alternatively, allowing for behaviour out of equilibrium. In the third part of the paper, we use a disequilibrium estimation method to obtain supply and demand equations. The conclusion draws together the results of the study and their implications.

Since deflators and relative prices are not available on a sufficiently detailed basis, it has not been possible to use disaggregated data in order to limit the effect of aggregation on the measurement of price and income elasticities. Magee (1975, p. 235) has stated succinctly the problem posed by aggregation. In the context of measuring a price elasticity, if, as is likely to be the case, an aggregate price change takes the form of large price changes for sub-categories that have low elasticities and small price changes for commodities with high elasticities, then the estimate of the price elasticity at the aggregate level will be biased downwards. The aggregate estimate gives correct results only if price changes at the disaggregated level are uniform or are uncorrelated with the weighted elasticities.

\*I would like to thank colleagues at the Central Bank, especially John Bradley and Colm McCarthy, seminar participants at University College Dublin and anonymous referees for comments and assistance on earlier drafts. The usual disclaimer applies.

## II SINGLE EQUATION MODELS

In this section we consider a number of single-equation models of export behaviour. Most econometric studies of foreign trade flows are of this type. In the case of exports, single-equation demand functions predominate. Such an approach ignores two econometric problems: identification and simultaneous equations bias. The problem of identification does not arise—the necessary order condition holds and the rank condition is satisfied (pathological cases aside)—if each of the supply and demand equations contains an exogenous variable that does not appear in the other equation. Thus, both equations are identified.

However, the estimation process will give biased results if ordinary least squares (OLS) is used for estimating a demand function without taking explicit account of a supply relation between quantity and price. This bias will be eliminated only if supply is infinitely elastic. It is also clear, on consideration of a simple supply/demand diagram (see Leamer and Stern, 1970, p. 30), that, if shifts in the supply schedule are large relative to those in the demand schedule, the bias in the coefficients of the export demand function will be reduced.

In the pure case, the standard assumption for a small country is that the demand for its exports is infinitely elastic, i.e., the small country is a price taker. If this were so, the main concern should be specification and estimation of an export supply function. However, it would seem to be too extreme to assume that even a very small country is a complete price taker; product differentiation in what are classified officially as identical products is likely to be such as to cast doubt on the assumption of a perfectly elastic demand curve. Consequently, we have specified alternately a single-equation demand for exports function and a supply of exports function.

### II. 1 A DEMAND FOR EXPORTS FUNCTION

The most commonly used functional form in empirical studies of export (and import) demand is, perhaps, the log-linear one. This has the advantage of allowing the dependent variable to respond proportionally to changes in the explanatory variables, and avoids the secular fall in elasticities implicit in the linear formulation. For these reasons, we have adhered to the log-linear formulation here.

The demand function is of the conventional type, in which export demand is related to world income and relative prices. (World income and world prices are computed as weighted indices of GNP and import unit values (i.e., tradables) in Ireland's eleven principal trading partners. See appendix for details.) The relative price index is adjusted to a numeraire currency, the

US dollar. Taking world prices and Irish export prices as a ratio rather than separately involves the assumption of no money illusion on the part of demanders. Although this is a hypothesis that could be tested, we adopt the traditional approach of imposing this assumption on the data.

As a first step, we assume an equilibrium relation so that desired demand for exports can be replaced by actual exports. This leads to an equation of the following form:

$$\text{Log } X = a + b \log P + c \log YW \quad (1)$$

where  $X$  is manufactured exports,  $P$  is the ratio of (Irish unit values for manufactured exports  $\times$  exchange rate index) to 'world' import unit values, i.e.,  $PX.R/PW$ , and  $YW$  is a world GNP index.

Four approaches were used in estimating this equation, in the first two of which world imports ( $MW$ ) was substituted for world income in order to preclude investigating lag structures on the scale variable. In the first case, an Almon lag was imposed on the price term after the maximal lag length was found by continually adding lagged price terms to equation (1). This maximal lag was found to be six or seven quarters.

With a lag length of seven quarters, second and third degree Almon polynomial structures were applied to the price term in equation (1), the scale variable used being world imports. (The Almon technique has the virtue of reducing the problems of loss of degrees of freedom and multicollinearity although clearly not eliminating the latter problem.) The second degree polynomial lag structure has the most plausible economic interpretation since it contains one mode, and is presented below as equation (2), with standard errors in parentheses.

$$\begin{aligned} \log X = & -2.64 + 2.32 \log MW - .29 \log P - .17 \log P_{-1} - .09 \log P_{-2} \\ & (.14) \quad (.07) \quad (.19) \quad (.06) \quad (.08) \\ & -.04 \log P_{-3} - .01 \log P_{-4} - .02 \log P_{-5} - .05 \log P_{-6} - .12 \log P_{-7} \\ & (.12) \quad (.13) \quad (.11) \quad (.15) \quad (.29) \\ \bar{R}^2 = & .98 \quad \text{DW} = 2.53 \end{aligned} \quad (2)$$

This equation is only moderately satisfactory, although its explanatory power is quite high and we cannot reject the hypothesis of zero autocorrelation at the 5 per cent level. Although all the coefficients on the price terms have the *a priori* correct signs, many of the t-ratios are small.

In the second version of equation (1), we imposed a number of arbitrary lag weights on the relative price term, retaining the maximal seven-quarter lag, and using world imports as an explanatory variable in lieu of world income. Although the mode of the lag on relative prices was varied from one to four quarters, the results were very similar to those of equation (2).

In the third approach to estimation of equation (1), we used prior information relating to the income elasticity of the demand for imports of Ireland's principal trading partners. It was not possible to obtain *both* short and long-run income elasticities of import demand for each country. The procedure adopted was to assume that the short and long-run income elasticities estimated for some countries in the project LINK model (Basevi, 1973) are representative of corresponding data for Ireland's eleven principal trading partners. The short and long-run income elasticities of import demand for SITC 5-9 products are available for Japan, Italy and Belgium only. The average implied geometrically declining lag was computed and applied to the long-run 'world' income elasticity of 2.16. A demand for exports function was then estimated using prior information on the lag structure for the world income effect. The lag structure postulated for the relative price term was, for the reasons given above, a seven-quarter one conforming to a second degree polynomial form. The equation estimated, however, had rather poor explanatory power and some of the price coefficients were positive. This unsatisfactory result might be due to the imposition of a uniform speed of adjustment on the income effect for all countries.

The final form of the demand function estimated is of the conventional Koyck type, implying the same geometrically declining lag on both independent variables, i.e., income and prices. Many authors (see, for example, Magee, 1975, p. 208 and Officer and Hurtubise, 1969, p. 320) have noted that the lag on prices is longer than on income. If this is the case for Ireland, the simple Koyck scheme would not be an appropriate model. However, the results of estimation are presented in equation (3).

$$\text{Log } X = -4.90 + 3.01 \text{ Log } YW - .36 \text{ Log } P + .45 \text{ Log } X_{-1} \quad (3)$$

(1.15) (0.71)            (0.18)            (0.13)

$$\bar{R}^2 = .988 \quad DW = 2.37$$

While, on the whole, this is not too unsatisfactory, the large sample Durbin test leads to rejection of the hypothesis of zero autocorrelation. The short-run income and price elasticities are 3 and  $-.4$ , respectively, while the corresponding long-run elasticities are estimated to be 5.45 and  $-.65$ , respectively. It is notable that, although equation (3) is not corrected for

autocorrelation, the (long-run) elasticities thrown up are quite similar to those estimated from equation (2).

Equation (3) has been re-estimated incorporating a first-order autocorrelation process on the disturbance term. This has been used in the literature as a means of taking account of changes in trade restrictions; the sample period, 1964 to 1974, was one of increasing trade liberalisation so that omission of an appropriate variable to take account of this might be expected to result in an autocorrelated disturbance term. An adjustment for first-order autocorrelation, combined with a standard stock-adjustment model from which equation (3) is derived, yields a reduced form equation with five unrestricted parameters to be estimated; it is possible to obtain unique estimates of the structural parameters from these unrestricted parameter estimates.

Desired export demand is specified (with the usual notation):

$$\log X_d = a + b \log YW + c \log P + u$$

The adjustment function is of the standard form:

$$\log X - \log X_{-1} = \lambda(\log X_d - \log X_{-1})$$

Combining these two relations yields:

$$\log X = \lambda a + \lambda b \log YW + \lambda c \log P + (1-\lambda) \log X_{-1} + \lambda u$$

When a first-order autoregressive scheme is assumed for the stochastic term, we get the following equation for estimation:

$$\log X = \lambda a + \lambda b \log YW + \lambda c \log P + (1-\lambda) \log X_{-1} + \lambda \rho u_{-1} + \lambda \epsilon$$

Since the reduced form equation for estimation has a lagged dependent variable on the right-hand side, OLS estimates are asymptotically biased. This bias is reduced by using  $\log X_{-2}$  as an instrument for  $\log X_{-1}$ . The results of estimation are presented in equation (4):

$$\log X = -5.73 + 3.51 \log YW - .39 \log P + .359 \log X_{-1} + .112 u_{-1} \quad (4)$$

(.120)(0.73)            (0.20)            (0.14)            (.155)

It should be noted that the hypothesis of zero autocorrelation is not rejected in this equation. This is not inconsistent with the autocorrelation test on the residuals from the Koyck equation (3), since one is not testing on similar residuals in the two cases. At this stage, it has not been possible to test for higher order autocorrelation. The long-run income and price elasticities of export demand work out at 5.48 and  $-.61$ , respectively.

In summary, although the export demand models postulated here are prone to errors of aggregation, the similarity of the results from the different equations is striking. The 'world' income elasticity of export demand

has been estimated to lie in the range 5.1 to 5.5, while the price elasticity lies in the implausibly low range  $-.6$  to  $-.9$ . The degree of bias in the estimates that might be expected if the liberalisation of trade restrictions was ignored does not appear to be large when these effects are approximated by assuming an autoregressive process on the error term.

## II. 2 A SUPPLY OF EXPORTS FUNCTION

It was noted above that concentration on specification of an export supply function rather than demand is more realistic for a small country, for which the price of tradeables is determined exogenously to a large extent. In this case, a country can, depending on its supply elasticity, export what it chooses, at the going price.

We postulate the following equilibrium export supply function here:

$$\text{Log } X = a + b \text{ Log } PS + c t \quad (5)$$

where  $X$  is the volume index of manufactured exports,  $PS$  is the ratio of the export unit value of manufacturers to domestic wholesale price index of more elaborately transformed goods and  $t$  is a time trend.

One could consider this equation to be based on a geometrical transformation curve explanation of exports, i.e., movements along the curve take place as a result of changes in the relative price line ( $PS$ ), while shifts in the transformation curve are taken account of by the trend term as a proxy for increases in the capital stock. The trend term represents the capacity of the exportables industries as growing exponentially.

An equilibrium supply equation based on equation (5) was estimated with, as in the single equation demand case, an Almon lag estimated for the price term. The maximal lag length found was 12 quarters; second and third degree Almon polynomials were then estimated with this lag length. The second degree equation is presented as equation (6):

$$\begin{aligned} \log X = & 1.32 + .018t + .50 \log PS + .35 \log PS_{-1} + .24 \log PS_{-2} \\ & (.02) (.001) (.17) \quad (.11) \quad (.07) \\ & +.14 \log PS_{-3} + .07 \log PS_{-4} + .03 \log PS_{-5} + .004 \log PS_{-6} \\ & (.06) \quad (.07) \quad (.09) \quad (.09) \\ & +.007 \log PS_{-7} + .03 \log PS_{-8} + .09 \log PS_{-9} + .16 \log PS_{-10} \\ & (.08) \quad (.07) \quad (.05) \quad (.06) \\ & +.26 \log PS_{-11} + .39 \log PS_{-12} \end{aligned} \quad (6)$$

$$\bar{R}^2 = .985$$

$$DW = 1.17$$

This is a reasonably satisfactory equation, although, in so far as can be judged from the limited tables available, the Durbin-Watson statistic is close to the region of rejection of the null hypothesis of zero autocorrelation at the 5 per cent significance level. All the price coefficients have the expected sign, although some are not statistically significant. The U structure on the lag coefficients is difficult to rationalise; a possible explanation might be that plants with spare capacity respond quickly to price incentives while enterprises that require to build new capacity need much more time to increase production.

The long-run price elasticity of supply given by equation (6) is 2.27, a plausible value for a country with a large exports/output ratio. (An estimate of roughly the same order of magnitude was obtained by Harrison (1972.)) It should be emphasised, however, that this is a tentative estimate given the single equation framework and the poor quality of the wholesale price index (based on fixed 1953 weights) and the export unit value index. Alternative domestic price indices were tried without much success.

### III A TWO-EQUATION MODEL OF EXPORT QUANTITIES AND PRICES

It was noted above that single-equation models of exports involve implicit assumptions that can bias equation estimates. It is only recently that two equation models have been specified and estimated in order to reduce the potential sources of bias. One such recent study (see Khan, 1974, and especially Goldstein and Khan, 1975) is outlined below and estimated for Irish data. This allows one to investigate the price responsiveness of both export demand and export supply.

#### III. 1 THE EQUILIBRIUM MODEL

The simpler of the two Goldstein-Khan models is an equilibrium one in which export quantities and prices adjust fully to their equilibrium values within one quarter.

The demand for, and supply of, exports are specified as follows:

$$\log X_d = a_0 + a_1 \log (PX.R/PW) + a_2 \log YW \quad (7)$$

$$\log X_s = b_0 + b_1 \log (PX/PD) + b_2 t \quad (8)$$

where the notation is as before except that the price variables are written more explicitly for the sake of clarity. The additional symbols are:

- PX: export unit values in £Ir.,  
 R: exchange rate index of the £Ir., in US dollars,  
 PW: weighted import unit values of Ireland's major markets, in US dollars,  
 PD: index of domestic prices (wholesale prices, more elaborately transformed products),  
 t: trend representing index of domestic capacity.

The expectation is that the elasticities in the supply function are positive. Re-writing the supply function with the price variable on the left-hand side, since it is convenient to normalise in order to have the two endogenous variables on the left-hand side of the two equations, yields:

$$\log PX = c_0 + c_1 \log X_s + c_2 t + c_3 \log PD \quad (9)$$

where:

$$c_0 = -b_0/b_1, c_1 = 1/b_1, c_2 = -b_2/b_1, c_3 = b_1/b_1$$

The price elasticity of the supply of exports,  $b_1$ , can be obtained as the reciprocal of the coefficient of  $c_1$  in equation (9). Equilibrium implies that  $X_d = X_s = X$ , and with the addition of stochastic terms to equations (7) and (9) we can estimate the equations simultaneously. The equations were estimated using the Full Information Maximum Likelihood (FIML) method which utilises all *a priori* restrictions on the two equation system. In the estimation, we impose the constraint that  $c_3 = 1$ . Thus, equation (9) is such that the structural parameters can be derived uniquely from the estimated coefficients of this equation.

The equilibrium model, i.e., equations (7) and (9), was estimated and is presented below:

$$\log X = -5.83 - 1.34 \log (PX.R/PW) + 5.25 \log YW \quad (10)$$

(.60) (.22) (.17)

$$\bar{R}^2 = .961$$

$$\log PX = -.31 + .221 \log X - .003t + 1.00 \log PD \quad (11)$$

(.06) (.04) (.001)

$$\bar{R}^2 = .985$$

These equations are quite satisfactory; all coefficients have the expected signs and the explanatory power is quite high. (It should be noted that the interval for  $\bar{R}^2$  is  $-\infty$  to 1 and not 0 to 1.) Although the Durbin-Watson test cannot be applied to the residuals in a simultaneous model, the pattern of residuals does indicate the presence of autocorrelation, especially in the



price equation. The model tracks the behaviour of exports and export unit values reasonably well over the sample period except for the start of the period in the case of the export quantity equation.

The structural parameters derived from the estimated  $c$ 's can be shown to be:

$$b_0 = 1.41, b_1 = 4.54, b_2 = 0.014.$$

### III. 2 THE DISEQUILIBRIUM MODEL

The second type of model specified by Goldstein and Khan (1975) introduces the possibility of disequilibrium behaviour. In this case, exports adjust to the difference between exports demanded in period  $t$  and the actual flow in the same period in the following way:

$$\Delta \log X = \gamma[\log X_d - \log X] \quad (12)$$

This adjustment function assumes that the quantity of exports adjusts to excess demand and, therefore, that the price of exports is determined in the exporting country.

Substitution of equation (7) in (12) yields the export quantity equation:

$$\log X = c_0 + c_1 \log (PX.R/PW) + c_2 \log YW + c_3 \log X_{-1} \quad (13)$$

where:

$$c_0 = \gamma a_0 / (1 + \gamma), c_1 = \gamma a_1 / (1 + \gamma), c_2 = \gamma a_2 / (1 + \gamma), c_3 = 1 / (1 + \gamma).$$

Clearly, one can obtain the structural parameters from the parameter estimates of equation (13).

Just as export quantities adjust to excess demand, so export prices adjust to excess supply as follows:

$$\Delta \log PX = \lambda[\log X - \log X_s] \quad (14)$$

Substituting equation (8) into equation (14) yields a disequilibrium price equation:

$$\log PX = d_0 + d_1 \log X + d_2 \log PD + d_3 t + d_4 \log PX_{-1} \quad (15)$$

where

$$d_0 = -\lambda b_0 d_4, d_1 = \lambda d_4, d_2 = \lambda b_1 d_4, d_3 = -\lambda b_2 d_4, \text{ and } d_4 = 1 / (1 + \lambda b_1).$$

Equation (15) contains five parameters, while there are four structural parameters. However, the five equations relating the five 'reduced form' to structural coefficients are not linearly independent; the linear constraint  $d_2 + d_4 = 1$  implies that we have four independent equations and four structural parameters. (It is worth noting that the Goldstein-Khan estimator



The demand elasticities are of a more realistic size than in the single equation case. On the other hand, it is difficult to rationalise the larger supply elasticity obtained from the equilibrium model. The supply elasticity given by the disequilibrium model is quite plausible and is similar to that obtained in the single equation case. It is noteworthy that the (long-run) income elasticities again come out at about 5.3.

In Table 2 we present some forecasts of export quantities and prices for 1975, using the reduced form equations derived from the two equation disequilibrium model.

Table 2: *Forecasts of export quantities, prices 1975 (indices, base average 1970=100)*

		<i>Export quantity</i>			<i>Export price</i>		
		<i>Actual</i>	<i>Forecast</i>		<i>Actual</i>	<i>Forecast</i>	
			<i>Static</i>	<i>Dymanic</i>		<i>Static</i>	<i>Dynamic</i>
1975	Q1	203.67	220	220	187.40	176	176
	2	198.18	224	227	196.88	184	174
	3	209.20	201	221	199.39	187	174
	4	201.47	214	221	212.56	189	174

It can be seen that the results are quite disappointing, although some of the forecasting errors may be attributed to the preliminary nature of some of the exogenous variables, especially world income, used for the forecast. In the static forecast, we insert the values of lagged endogenous variables (as well as values of exogenous variables), while the dynamic forecast uses the model estimates as values of lagged endogenous variables. The model generally overpredicts export quantities— by about 5½ per cent on average in the case of static forecasts, and systematically underpredicts export prices. It should be borne in mind, however, that 1975 was the first year for the period examined in which export quantities were significantly down on the levels of the previous year (see appendix data). In addition, the world unit value index used in the equations relates to *all* world imports. This is liable to give rise to problems after 1973, when the large increase in oil prices dominated the movement in import unit values. Although our simple model does pick up the downturn with the *ex post* forecast, albeit with a lag, it would probably require a much more sophisticated disaggregated set of equations to model adequately export behaviour in 1975.

#### IV A DISEQUILIBRIUM MODEL OF MANUFACTURED EXPORTS AND PRICES

In this section we outline and estimate an export model on the basis of a methodology applied recently to the behaviour of UK exports. (See Hutton and Minford, 1975.) This model emphasises the rigidity of prices in the short-run principally because of costs of adjustment and the existence of contracts. Thus markets are not cleared instantaneously, through price-adjustments, but rather through the speculative behaviour of firms and consumers which leads them respectively to build up stocks and join queues rather than accept prices significantly different from the long-run price expected. Prices are assumed fairly stable around full cost levels.

The methodology of the model operates by specifying observed export quantities as either demand or supply on the basis of a criterion of capacity utilisation. If capacity utilisation in manufacturing industry is less than 95 per cent in a time-period, there is considered to be excess supply and what one observes therefore is (*ex ante*) demand. On the other hand, if capacity utilisation is greater than 95 per cent, there is excess demand and one observes (*ex ante*) supply. In fact, in the latter case, it is hypothesised that what one observes is *ex ante* supply plus some part of the excess demand over supply.

Thus the model, for any period  $t$ , is:

$$Q = X_d, \text{ for excess supply periods} \quad (18)$$

$$\text{and } Q = X_s + (1-w)(X_d - X_s), \text{ for excess demand periods} \quad (19)$$

The excess demand period observation can also be written as a weighted average of the supply and demand curves, i.e.,

$Q = wX_s + (1-w) X_d$ , where  $Q$ : observed export quantity,  $X_d$ : export demand,  $X_s$ : export supply.

There are many alternative models that one might specify besides that implied by equations (18) and (19). One such model in which  $Q = X_d$  for all periods is rejected because of the high inventory costs implied if suppliers are to hold sufficient stocks to ensure that export demand never goes unsatisfied (switching supplies from the domestic to the export market to ensure that export demand is always satisfied is not considered plausible in view of the higher costs involved in export sales). Another disequilibrium model that has appeared in the literature (see Fair and Jaffee, 1972) specifies the quantity observed to be the minimum of demand and supply, i.e.,  $Q_t = \min (X_d, X_s)$ . However, this is rejected for the unreasonable implied

assumption of no stocks being held and no queues developing. The model specified by equations (18) and (19) does not permit export queues to form and carry over into excess supply periods, although it does assume that stocks play an important role in clearing the market in excess demand periods.

The first step in the estimation procedure is to distinguish demand from supply periods. A capacity utilisation of 96 per cent is taken as the pivotal value for distinguishing excess demand from excess supply periods. (A pivotal value of 95 per cent would have yielded too few demand observations.) Periods for which capacity utilisation is less than 96 per cent are classified as excess supply periods and yield, therefore, demand observations. Similarly, periods for which capacity utilisation is greater than 96 per cent are deemed to be excess demand periods and yield supply (or supply modified) observations.

The method proceeds by estimating a demand and a supply function using the demand/supply observations determined on the basis of the capacity utilisation criterion. From the estimated demand and supply schedules, demand and supply are estimated for *all* periods. Export observations are re-classified as belonging to either the demand or supply regime according as  $X_d$  is less than or greater than  $X_s$ . On the basis of the new set of demand and supply observations, the two schedules are re-estimated, and observations are reclassified once more if necessary. The procedure continues until no further reclassification of observations is necessary. Observations can be classified as both demand and supply if the difference between *ex ante* demand and supply is less than a specified tolerance. (It should be noted that, as in the UK study, the 'supply' function estimated is a modified supply function—equation (19) above.)

The form of the demand and supply functions postulated is, omitting stochastic terms and denoting a distributed lag on a variable by (L):

$$\log X_d = a_0 + a_1 \log MW + a_2(L) \log (PX.R/PW)$$

$$\log X_s = b_0 + b_1 t + b_3(L) \log (PX/PD)$$

(A definitional type supply function as used in the UK study was also attempted.) The latter two equations, when recast in the form of equations (18) and (19), yield the following model for estimation:

$$\ln X_d = a_0 + a_1 \log MW + a_2(L) \log (PX.R/PW) \quad (20)$$

$$\log Q = w(b_0 + b_1 t + b_2(L) \log (PX/PD)) + (1-w) \log X_d \quad (21)$$

When equation (21) is estimated, one can derive the supply schedule, since the coefficient on  $\log X_d$  yields an estimate of  $w$ .

The first step therefore is to estimate the pure demand function, equation (20), from the set of 20 demand observations obtained by using the capacity utilisation criterion. It was not clear from a preliminary examination what the maximal lag length on the price term was; a lag length of four to seven quarters gave almost similar results. The pure demand function with a 7-period second degree Almon lag is presented as equation (22):

$$\begin{aligned} \log X_d = & -2.59 + 2.30 \log MW - .07 \log (PX.R/PW) - .14 \log (PX.R/PW)_{-1} \\ & (0.54) (0.27) \quad (.44) \quad (.14) \\ & -.18 \log (PX.R/PW)_{-2} -.19 \log (PX.R/PW)_{-3} -.18 \log (PX.R/PW)_{-4} \\ & (.17) \quad (.27) \quad (.31) \\ & -.14 \log (PX.R/PW)_{-5} -.07 \log (PX.R/PW)_{-6} + .02 \log (PX.R/PW)_{-7} \\ & (.34) \quad (.48) \quad (.80) \end{aligned} \quad (22)$$

$$\bar{R}^2 = .952 \qquad DW = 2.53$$

This equation gives poor results; none of the relative price coefficients are well-determined with one positive sign appearing.

Notwithstanding the poor results for the pure demand function, the complementary supply-modified function, equation (21), was estimated. Again, it was not possible to establish clearly the maximal lag length. Since this equation is dependent on equation (22) above in that estimated (*ex ante*) demand for "supply" periods is estimated from equation (22), the supply-modified function estimated is only of academic interest. An equation of the form of (21) above was estimated with a lag of 12 quarters on the price term. The actual supply function derived from this was:

$$\log X_s = 1.267 + 2.91 (L) \log (PX/PD) + .0197t \quad (23)$$

The long-run supply elasticity is 2.9, and the implied potential quarterly growth in the capacity of manufacturing industry is almost 2 per cent.

The definitional type supply function used in the UK study was also estimated using the "supply" observations obtained from the capacity utilisation criterion. The resulting equation, however, had a consistently insignificant coefficient on the domestic demand for exportables variable. This may reflect either the inadequacy of the measure used for this variable or the frequently noted dualism in Irish industry with certain firms producing almost exclusively for export; there are problems of aggregation also, of course.

In summary, this initial attempt to apply the Hutton-Minford disequilibrium analysis to aggregate manufactured exports data has not been successful. The methodology does not yield reasonable results on the basis of the initial dichotomy of export observations into supply and demand, since the demand function is not well-determined and consequently does not allow us to proceed to estimation of the supply (modified) function. This prevents iteration to converge to a set of demand and supply observations from which more precise forms of the demand and supply functions could be obtained. It is worth noting also that the properties of these estimators have not as yet been well established.

Since the export quantity equation was not successfully estimated, no attempt was made to estimate the export pricing equation suggested by Hutton-Minford; this equation is of the conventional kind and relates export prices to domestic costs and competitors' prices.

## V SUMMARY AND CONCLUSIONS

In this paper we have specified and estimated a number of simple models of manufactured exports behaviour using quarterly data over the period 1964 to 1974. Such models are of interest generally if they help to establish the determinants of manufactured exports, and in particular if they provide estimates of important parameters such as the price elasticities of supply and demand and the income elasticity of demand.

Single equation models of supply and demand were estimated, although the implicit assumption of infinitely elastic supply is so unrealistic for a small country with a high exports/output ratio that single equation demand models are likely to give biased results. For a small country, single equation supply models are less subject to bias, since the assumption of infinitely elastic demand may not be very different from reality.

Comparison of the single equation results with the simultaneously estimated two-equation models of supply and demand supports the *a priori* expected bias in single equation models. Of the two simultaneous models estimated, the disequilibrium one fitted the data somewhat better than the equilibrium; there was less evidence of autocorrelated errors in the former case and a quarterly model is likely to be mis-specified if full adjustment to equilibrium within a quarter is imposed. The price elasticities of supply and demand obtained from the disequilibrium model were 2.33 and -1.44, respectively. (Goldstein and Khan's (1975) corresponding results for Belgium were 1.7 and -0.73, and for the Netherlands 2.1 and -2.54.) The supply price elasticity is reasonable; the demand price elasticity is small by com-

parison with what might be expected for a small country, although this sort of result is supported by the relatively small weight that Kennedy and Dowling (1975) attributed to competitiveness (in a broad sense) in determining the growth of manufactured exports between 1953 and 1968.

Increases in domestic costs and prices affect exports through the supply function by reducing the profitability of exporting, while increases in productive capacity serve to increase exports.

An attempt to take account of the effects on exports of trade liberalisation, by assuming an autoregressive process on the error term in the single equation demand functions, suggested that trade liberalisation does not materially affect the results. The relative insignificance of the direct trade effect of trade liberalisation, as measured in empirical studies, has been noted by McAleese (1970); this is not to say that these effects are of negligible importance or that other methods of analysis would not find them to be significant. Again, export subsidies in the form of cash grants and tax reliefs do not distort the results, as these were largely unchanged over the period examined, 1964 to 1974. An evaluation of the effects of these schemes would appear to require studies of behaviour at the individual firm level.

#### REFERENCES

- BASEVI, G., 1973. "Commodity trade equations in project link" in R. J. Ball (ed.): *The International Linkage of National Economic Models*, Amsterdam: North-Holland.
- CENTRAL STATISTICS OFFICE, 1970. *Input-Output Tables for 1964*. Dublin: The Stationery Office. (Pr. 985).
- COPELAND, J. R. and E. W. HENRY, 1975. *Irish Input-Output Multipliers 1964 and 1968*. Dublin: The Economic and Social Research Institute, Paper No. 82.
- FAIR, R. and D. JAFFEE, 1972. "Methods of estimation for markets in disequilibrium", *Econometrica*, Vol. 40, No. 3.
- GOLDSTEIN, M. and M. S. KHAN, 1975. "The supply and demand for exports: a simultaneous approach", paper presented at *The Third World Congress of the Econometric Society*, Toronto.
- HARRISON, M. J., 1972. "The elasticity of demand for Irish exports", in A. A. Tait and J. A. Bristow (eds.): *Ireland—Some Problems of a Developing Economy*. Dublin: Gill and Macmillan.
- HENRY, E. W., 1972. *Irish Input-Output Structures 1964 and 1968*. Dublin: The Economic and Social Research Institute, Paper No. 66.
- HUTTON, J. and P. MINFORD, 1975. "A model of UK manufactured exports and export prices". *Government Economic Service Occasional Paper*. London: HMSO.
- KENNEDY, K. A. and B. R. DOWLING, 1975. *Economic Growth in Ireland: The Experience since 1947*. Dublin: Gill and Macmillan.
- KHAN, MOHSIN S., 1974. "Import and export demand in developing countries", *Staff Papers*, International Monetary Fund, Vol. 21, No. 3.
- LEAMER, E. E. and R. M. STERN, 1970. *Quantitative International Economics*. Boston: Allyn and Bacon.
- McALEESE, DERMOT, 1970. "Quantitative estimates of trade liberalisation—methods and results", *The Economic and Social Review*, Vol. 2, No. 1.



- McMAHON, PATRICK C. and DAVID J. SMYTH, 1974. "Capacity utilisation in Ireland", *The Economic and Social Review*, Vol. 6, No. 1.
- MAGEE, STEPHEN P., 1975. "Prices, incomes and foreign trade", in P. B. Kenen (ed.): *International Trade and Finance: Frontiers for Research*. London: Cambridge University Press.
- OFFICER, LAWRENCE H. and J. R. HURTUBISE, 1969. "Price effects of the Kennedy round on Canadian trade", *Review of Economics and Statistics*, Vol. 51, No. 3.
- O'REILLY, L., 1976a. "An account of the quarterly interpolation programme of Boot, Feibes and Lisman", Dublin: *Central Bank of Ireland* (mimeo.).
- O'REILLY, L., 1976b. "Estimating quarterly national accounts", *Central Bank of Ireland* (mimeo.).

## APPENDIX: DATA AND SOURCES

### *Exports of Irish Manufactured Goods*

Quarterly data on the value of Irish manufactured exports (SITC 5-8) were obtained from the Trade Statistics of Ireland back as far as 1964, the first quarter of which was the first quarter for which aggregate manufactured exports were required. However, since world prices and world activity were calculated as a weighted average of prices and activity in Ireland's principal trading partners, it was necessary to obtain quarterly data on exports by destination.

The procedure adopted was to take annual exports of manufactured goods to Ireland's 10 principal trading partners (excluding the UK, for which quarterly manufactured exports are available) for each year back to 1960. These countries are US, Germany, Netherlands, Switzerland, France, Belgium, Canada, Japan, Italy and Sweden. (Data were obtained for a number of years prior to 1964 in order to permit experimentation with various lag lengths.) These 10 countries (together with the UK) accounted for more than 85 per cent of manufactured exports in each year covered. To avoid unrealistically large discrete changes in the trade weights that would be obtained by assuming that annual trade weights apply for each of the four quarters of a year, we have used an interpolation method to obtain quarterly trade weights. The interpolation method used (see O'Reilly, 1976a) is such that the sum of the squared differences of successive quarterly values is minimised subject to the constraint that the four quarterly values sum to the annual value; the resulting values have certain desirable properties. Quarterly manufactured exports to the UK were seasonally adjusted using the X-11 program.

In working the data back to 1960, it was necessary to make certain assumptions about the distribution of manufactured exports for the years 1960 to 1962 inclusive. From the "External Trade Statistics" publications for those years, exports categorised as Class III were adjusted for certain categories of goods that are clearly not manufactures. The proportion of these Class III

(adj.) exports accounted for by the 11 principal trading partners was then applied to annual SITC 5-8 exports to obtain an annual estimate of these exports accounted for by these countries between 1960 and 1962. The resulting annual figure was distributed over the 11 countries in proportion to Class III (adj.) exports to those countries. Quarterly interpolations were then obtained from these annual manufactured exports by destination.

#### *Export Prices of Manufactured Goods*

The export unit value index for "other goods" was used as an indicator of the export price of manufactures. This is, of course, subject to the problems associated with all unit value indices—in particular, tariffs are assumed to be a fixed proportion of the export price and, secondly, a unit value index does not measure the price of *specific* commodities and can give, therefore, a distorted picture of actual price changes simply as a result of a change in the composition of an export category. Where the export price index is required to be expressed in a numeraire currency, the US dollar was taken as the numeraire. A quarterly index of the number of US dollars per Irish pound was obtained from International Financial Statistics (IFS); average daily rates were used where possible, otherwise average end-month exchange rates were used.

#### *World Prices, World Activity*

As indicated above, indices of world prices and world activity were obtained using as weights the quarterly direction of Irish manufactured exports. It was not possible to obtain quarterly indices of domestic prices in each of Ireland's 11 principal trading partners. Although these indices could have been interpolated quarterly, it was considered more appropriate to use quarterly indices of import prices or, more precisely, unit values. The latter are better on theoretical grounds, since we are interested primarily in the price of *tradeable* goods, and it can be assumed that the price of imports in a country moves fairly closely in line with the domestic prices of tradeables. In some instances, IFS contained two import price indices, one for raw materials and one for imports generally; the latter was taken as the most reasonable indicator of import prices of manufactures. Import prices for each of the 11 countries were expressed in the numeraire currency (US dollar), using quarterly exchange rates against the dollar. The resulting dollar import price indices were averaged, the weights being the quarterly weights of each country in Irish manufactured exports.

Two indices of world activity were taken:

- (1) imports of Ireland's major export markets, (2) GNP in these markets

(for a number of countries, GNP data were not available and therefore GDP was used). The imports series was obtained from IFS, while the source for GNP/GDP was country reports of the OECD and the National Institute Economic Review.

#### *Domestic Demand for Exportables*

An index of the domestic demand for manufactured exportables was constructed using a method suggested by Hutton and Minford (1975). This volume index is a weighted average of consumption, investment and public authorities' current expenditure. The weights for each expenditure category were calculated as  $\sum W_i S_i$ , where  $i$  ranges over Irish manufacturing industries (as set out in the 1964 and 1968 Input-Output tables),  $W_i$  is each industry's share in total manufactured exports, and  $S_i$  is the share of the expenditure category (both direct and indirect as obtained from the  $(1-A)^{-1}$  principal diagonal) in the industry's output in 1964 and 1968. Data relating to 1964 were taken from Tables A.1 and A.3 of the Input-Output tables for 1964 (Central Statistics Office, 1970). The same data for 1968 were taken from Henry (1972, Appendix 3.3) and from Copeland and Henry, (1975, Appendix 4.1). The resulting weights for the expenditure categories were then adjusted to sum to unity. The weights derived from the 1964 Input-Output tables for consumption and investment were .8124 and .1876, respectively. (The weight for public authorities net current expenditure is zero, as the I-0 tables indicate that no purchases were made by government from manufacturing industries. This peculiar result may be due to errors in compiling the I-0 tables.) The corresponding weights from the 1968 Input-Output tables were .7680 and .2320. The weights obtained from the 1964 tables were applied to indices of the volume of consumer expenditure and of gross domestic physical capital formation (GDPCF). These latter concepts were taken, since quarterly data on the *value* of these have been estimated by O'Reilly, 1976b. Quarterly estimates of consumer expenditure and GDPCF in constant prices were obtained by deflating by the Consumer Price Index and the wholesale price of capital goods, respectively. When the resulting volume indices were seasonally adjusted, the respective weights obtained from the 1964 I-0 tables, i.e., .8124 and .1876, were applied to calculate a domestic demand for exportables index.

#### *Capacity Utilisation Index*

An index of capacity utilisation was constructed using the Wharton method. This consists in assuming that manufacturing output peaks represent full capacity utilisation, and that full capacity utilisation in other periods may be obtained by linear interpolation or extrapolation. Output is taken to

Table of series used

Date	Exports of Manu- factures (Volume)	Unit Value Index- Other Goods (£fr.)	Exchange Rate Index (No. of \$/£fr.)	"World" Income	"World" Imports	"World" (Import) Prices	Domestic Demand for Export- ables	Domestic Price of Tradeables	General Whole- Sale Prices	Wholesale Prices More Elaborate Products	Capacity Utilisa- tion Index	
1961	1	—	76.43	116.63	75.62	62.51	88.86	65.59	64.24	69.22	64.71	—
	2	—	75.47	116.34	76.39	60.67	90.10	65.69	64.75	69.72	65.42	—
	3	—	77.55	116.88	76.50	57.69	88.87	65.41	64.99	69.58	66.14	—
	4	—	78.10	117.16	76.85	60.28	89.07	66.02	65.25	70.04	66.87	—
1962	1	—	75.57	117.23	77.00	62.45	89.00	69.50	66.29	71.13	67.76	—
	2	—	76.57	117.10	78.28	62.63	88.93	68.24	67.23	72.27	68.97	—
	3	—	78.42	116.78	78.66	61.39	88.49	67.57	67.64	72.19	69.44	—
	4	—	77.14	116.76	78.13	63.28	88.63	71.25	67.82	71.89	69.61	—
1963	1	—	74.81	116.76	77.37	62.17	90.26	69.79	67.96	72.41	69.75	—
	2	—	76.02	116.69	77.59	64.30	90.96	72.60	68.26	72.77	69.99	—
	3	—	77.08	116.63	81.01	64.23	90.78	72.52	68.80	72.77	70.28	—
	4	—	77.05	116.56	82.37	68.07	91.94	75.92	70.41	72.96	70.65	—
1964	1	46.38	76.75	116.59	83.97	70.88	93.75	74.97	71.06	74.94	71.95	99.6
	2	45.83	77.25	116.53	85.30	72.58	93.92	76.23	73.23	77.29	74.06	100.0
	3	46.11	77.35	116.05	85.64	69.82	92.67	78.20	74.63	77.74	74.60	98.3
	4	50.01	74.08	116.20	86.22	73.15	93.65	77.07	74.91	78.12	75.05	97.1
1965	1	44.02	73.67	116.35	86.74	69.12	93.81	79.76	75.24	79.39	75.34	97.4
	2	49.39	74.40	116.44	86.42	73.43	84.04	80.03	76.28	80.59	76.75	96.8
	3	56.33	75.95	116.46	87.11	72.56	93.40	78.23	77.00	79.94	77.57	94.8
	4	51.56	76.55	116.82	88.14	75.71	94.58	77.30	77.16	79.66	77.83	94.4
1966	1	56.13	77.67	116.63	88.84	77.67	95.21	75.20	77.38	80.75	78.36	92.6
	2	50.14	79.82	116.32	88.74	75.55	96.37	76.57	78.05	82.43	79.91	87.7
	3	56.08	80.20	116.26	89.50	76.24	95.63	82.19	79.51	81.56	81.14	93.7
	4	61.38	81.30	116.30	89.29	74.41	95.79	79.49	80.30	81.36	81.87	91.5
1967	1	59.37	84.52	116.46	89.70	81.21	95.63	81.47	80.74	82.76	82.05	93.6
	2	62.22	84.14	116.44	90.74	82.44	94.20	79.81	80.93	84.07	83.66	93.1
	3	59.51	84.20	116.19	90.93	77.09	94.72	81.39	80.84	83.22	83.79	91.4
	4	64.39	85.68	165.70	91.50	83.85	91.49	82.86	81.80	84.42	84.28	91.2
1968	1	74.41	88.01	100.24	93.39	90.63	92.05	85.53	82.88	87.21	85.28	94.0
	2	78.14	88.56	99.50	93.97	89.38	91.62	89.08	83.46	88.65	96.67	95.9
	3	79.68	91.06	99.56	94.94	89.34	91.65	91.93	84.31	88.63	87.53	96.5
	4	82.58	93.34	99.45	96.48	93.09	92.49	94.53	84.79	89.99	89.48	96.1

Table of series used (continued)

Date	Exports of Manufactures (Volume)	Unit Value Index- Other Goods (£/Ir.)	Exchange Rate Index (No. of \$/£Ir.)	"World" Income	"World" Imports	"World" (Import) Prices	Domestic Demand for Exportables	Domestic Price of Tradeables	General Wholesale Prices	Wholesale Prices More Elaborate Products	Capacity Utilisation Index
1969 1	82.51	91.21	99.70	96.36	91.38	93.53	92.64	88.35	93.02	92.03	91.6
2	87.50	92.45	99.57	97.33	97.58	94.15	100.54	90.22	95.29	93.72	100.0
3	89.39	96.42	99.40	98.53	93.08	95.39	99.69	90.89	95.41	95.39	97.8
4	87.25	96.72	99.90	98.53	96.61	97.63	100.43	92.30	96.16	95.67	96.6
1970 1	92.91	98.62	100.00	98.60	95.76	99.42	99.91	93.56	98.61	98.26	95.4
2	95.85	99.97	100.00	99.84	103.79	99.93	97.38	96.66	100.61	99.50	95.4
3	97.38	100.56	100.00	100.43	95.39	99.98	100.54	103.87	100.31	100.89	100.0
4	113.85	100.86	100.00	101.14	105.06	100.67	102.17	105.93	100.47	101.36	97.5
1971 1	110.16	102.68	100.00	100.88	104.29	102.51	106.61	106.94	103.59	103.32	95.5
2	117.68	104.10	100.00	101.71	106.60	104.96	101.67	109.87	105.63	105.31	95.2
3	114.73	106.30	100.96	102.99	101.72	106.24	101.31	111.23	105.67	106.66	94.6
4	120.52	106.44	104.29	106.56	111.74	112.08	103.70	113.21	106.78	107.83	94.0
1972 1	127.71	108.93	108.29	103.57	112.96	112.96	106.25	117.71	111.87	109.88	92.0
2	135.25	109.37	108.30	105.71	115.04	114.17	107.11	119.56	114.28	111.04	92.6
3	150.87	114.09	101.86	106.45	108.13	112.39	107.59	121.49	117.21	114.02	93.0
4	160.84	117.07	98.51	108.44	125.94	113.76	114.80	123.85	122.33	118.19	95.3
1973 1	174.77	125.56	100.79	111.31	131.38	122.24	117.13	127.08	131.00	121.04	98.5
2	182.07	130.67	105.40	111.46	130.30	136.59	119.70	129.96	137.36	124.76	98.2
3	185.52	137.00	103.54	111.74	126.17	147.11	119.88	134.28	139.26	132.27	97.5
4	206.41	141.74	99.10	112.10	135.98	154.49	109.65	137.48	139.94	134.34	94.9
1974 1	209.98	149.67	94.97	112.14	130.75	175.63	118.71	144.34	147.92	142.05	100.0
2	216.41	162.72	99.89	110.57	134.11	203.36	116.29	156.35	154.74	148.37	96.1
3	216.31	173.52	99.95	110.34	130.88	206.02	114.55	169.65	156.44	156.39	93.4
4	213.75	178.83	97.04	110.85	130.53	210.93	112.20	173.61	162.52	162.78	89.4
1975 1	203.67	187.40	99.63	109.32	—	224.10	—	186.50	184.50	181.13	86.3
2	198.18	196.88	96.86	112.40	—	220.20	—	193.89	194.84	190.50	83.3
3	209.20	199.39	88.64	107.70	—	207.70	—	195.89	193.90	—	82.0
4	201.47	212.56	85.13	108.40	—	208.50	—	200.20	—	—	—

Note: Exports of Manufactures, 'World' Income and 'World' Imports are seasonally adjusted using the Bureau of Census X-11 method or a quarterly interpolation programme, and are in constant price terms. All series, except the last, are in index number form, base average 1970=100. The sources for the second, ninth and tenth columns of data is the *Irish Statistical Bulletin*, Central Statistics Office, Dublin.

have a peak in a period, if output exceeds the level of the preceding quarter and of the two succeeding quarters. Although this is the basic decision rule, following McMahon and Smyth (1974), when output remains on a plateau before declining, or when output declines from a peak for one quarter before returning to that level, then, under the assumption that capacity is rising over time, the first period on the plateau or the first peak is chosen as full capacity output. The McMahon/Smyth index was not used, because of the computational problems involved in continuing their series beyond 1972, the last year of their series. As might be expected, for the period up to 1972, our series follows closely that of McMahon/Smyth.

### *Domestic Prices*

The principal index of domestic prices used in the supply functions is the Wholesale Price Index of the output of industry, more elaborately transformed products.

Notwithstanding the fact that it is constructed on the basis of fixed 1953 weights and commodity lists, this index appears to be the best available quarterly index of the domestic price of manufactures.

An alternative index used in the empirical work was the general wholesale price index.

A third index was constructed—the domestic price of tradeables. This was obtained as the weighted average of three subcategories in the Consumer Price Index, i.e., clothing/footwear, durable household goods and other goods. (The last category included services before 1969.) The weights used were .2973, .1941 and .5085, respectively, reflecting the relative weights in exports in 1971 as obtained from the disaggregated external trade statistics for that year. The resulting domestic price of tradables index has three principal deficiencies: (a) it relates only to items measured in the CPI, (b) it reflects changes in expenditure taxes and subsidies, (c) the three CPI subcategory indices themselves represent the changes in price of the basket of goods within each of the three categories; this basket may differ substantially from the composition of exports within each subcategory.