IMPORT FORECASTS FOR INPUT-OUTPUT MODELS*

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The paper presents forecasting models for (1) the share of competitive imports in the total demand for a commodity group and (2) the level of demand for competitive imports of a commodity group. The two forecasting models are used, respectively, with (1) input-output models which incorporate market share parameters as one vector of coefficients and (2) input-output models which assume imports have been determined autonomously. It is shown that these two types of input-output models can be made workable by prefixing one or other of the import forecasting models to the input-output model. Tests are made of the forecasting ability of the combined models.

Input–output models are used for making forecasts of industry output from a given set of final demands and some assumption about the import content of total demand. One class of input–output models, which we shall refer to as Type I models, makes the assumption that there is an import market share parameter which is either constant or which changes in a predictable manner. Another class of models, which we shall refer to as Type II models, assumes that imports are determined exogenously.[1] For this class of model, imports must be forecast outside the input–output model. This paper considers how to make these two types of input–output models workable by developing models for forecasting the market share of imports or the level of imports which can then be used in conjunction with Type I or Type II input–output models, respectively.

A prior condition for the workability of input–output analysis in the manner in which it is used in this paper is the assumption that a macroeconomic model is available and is used to make forecasts of the components of final demand (such as personal expenditure on consumer durable goods). These forecasts may then be translated by a matrix of coefficients, such as that obtainable from an input–output table showing a comparable disaggregation of final demand, into a forecast of final demand by commodity groups. The specific problem investigated by this paper is how to produce (1) an estimate of the market share parameter for each commodity class of imports for Type I input–output models or (2) an estimate of the total demand for each commodity class of imports for Type II

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[1] See Models II and III of T. I. Matuszewski, P. R. Pitts, and J. A. Sawyer, "Alternative Treatments of Imports in Input-Output Models, A Canadian Study," *Journal of the Royal Statistical Society*, CXXXVI (1963), 410–432.

input–output models, in order that the forecast of total final demand for a commodity group can be translated into a forecast of demand for domestically-produced commodities by commodity group or industry.[2]

For the experiments reported on in this paper, a Canadian input–output table for 1949 was used.[3] This table is an interindustry table which shows the industry of origin of inputs into each industry and, therefore, the industry of destination of the output of each industry. The original 42 × 42 table was aggregated into a 29 × 29 table for the present study, of which 17 were manufacturing industries, 6 were resource industries, and 6 were service industries. The experiments assume that the macroeconomic model forecasts the components of final demand without error and that forecasts of other exogenous variables in the forecasting models are also made without error.

1. The Market Share of Competitive Imports

The Type I input–output model of this paper utilizes a parameter $m_i = y_i/x_i$, where x_i is the domestic output of the ith commodity and y_i is competitive imports of the ith commodity. Forecasting errors can result either from instability in the m_i, which relates to the share of imports in the market, or from instability in the matrix of technical input–output coefficients.

We tried to explain the behavior of the market share parameter for the 6 resource and 23 manufacturing industries, using data on m_i for the period 1947–1956 ($i = 1, \ldots, 23$). We then used this explanation to "forecast" the values of m_i for the years 1957–1958. Unfortunately, data were only available on imports on a basis consistent with the 1949 input–output table for the years 1947–1958.

The explanation is in terms of the following three factors:

(i) The price of competitive imports relative to domestically-produced output. Let p_i be a price index of the input of the ith domestic industry, f.o.b. the producing establishment and excluding all sales and excise taxes levied after the final stage of production is completed.[4] Let q_i be a price index of competitive imports, c.i.f. the border, including customs import duties but excluding all excise

[2] We assume that the industry output levels we desire to forecast are constant dollar values. Some experiments have been reported where forecasts made using current dollar coefficients have been better than forecasts made using constant dollar coefficients. See C. B. Tilanus and G. Rey, "Input-Output Volume and Value Predictions for the Netherlands, 1948–1958," *International Economic Review*, V (January, 1964), 34–35, and C. B. Tilanus, *Input-Output Experiments: The Netherlands*, 1948–1961, (Rotterdam: Rotterdam University Press, 1966), pp. 52 ff. See also John Haldi: "A Test on Two Hypotheses Concerning Interpretation of Input-Output Coefficients," *Weltwirtschaftliches Archiv*. LXXXIII (1959), 1–13. If we had forecast output in current dollars, it would have been necessary to forecast price indexes to arrive at constant dollar output levels for insertion into production function to obtain forecasts of employment and capital demands.

[3] Dominion Bureau of Statistics, *Supplement to the Interindustry Flow of Goods and Services, Canada*, 1949, Publication No. 13–513, (Ottawa: Queen's Printer, 1960). A later table which is a rectangular commodity-by-industry table is now available. Dominion Bureau of Statistics, *The Input-Output Structure of the Canadian Economy*, Publication No. 15–501 (Ottawa: Queen's Printer, 1969), Volumes I and II.

[4] In the case of alcoholic beverages and tobacco products, excise duties are included since the customs import duty is set to be equivalent to these duties on domestic output.

and sales taxes. These *ad valorem* sales and excise taxes apply equally to domestically-produced goods and to imports; hence their exclusion from both price indexes does not affect the relative price ratio. Let r_i be the relative price, where $r_i = (q_i/p_i) \times 100$.

(ii) A measure of excess capacity in Canadian manufacturing industries devised by Lithwick, Post, and Rymes.[5] The thirteen manufacturing industry groups used by Lithwick, Post, and Rymes did not correspond to our groupings in some cases. No data were readily available to adjust their groupings to ours, and, therefore, we applied their groups to ours as best we could. The value of the excess capacity variable (in millions of 1949 dollars) is denoted by c_i.

(iii) A shift variable to take into account the import controls imposed in 1948.[6] These controls had their maximum effect in 1948 and approximately half that effect in 1949. This variable, s_t, was, therefore, given the value 1.0 in 1948 and 0.5 in 1949. In all other years it had the value zero.

Our model is therefore

$$(1) \qquad m_{it} = \beta_{i0} + \beta_{i1}c_{it} + \beta_{i2}r_{it} + \beta_{i3}s_{it} + u_{it};\ i = 1, \ldots, 23 \quad t = 1, \ldots, 10$$

where $t = 1$ means 1947, and where u_{it} is an independently distributed random disturbance assumed to have zero expectation, constant variance, and not to be correlated with the right-hand side variables of the equation. Despite the fact that the last assumption is undoubtedly violated, direct least squares were used to estimate the β's.[7]

According to the theory underlying the construction of our model, the parameters β_1, β_2, and β_3 for all industries should be negative. We noted that in four equations, however, the price ratio variable had the wrong sign. The excess capacity variable, c, had the wrong sign in six equations.[8] The dummy variable, s, whose purpose was to allow for the import controls in 1948–1949, had the wrong sign in only one case.[9]

Forecasts of the market share parameter for each of the twenty-nine industries for the years 1957 and 1958 were then made from the regression equations which had been fitted to data for the period 1947–1956.

The following test was made of the usefulness of these forecasts of market share parameters. Using a Type I input–output model and the 1949 matrix of technical input–output coefficients, forecasts were made for 1957 and 1958 of the

[5] N. H. Lithwick, George Post, and T. K. Rymes, "Post-War Production Relationships in Canada," in National Bureau of Economic Research, Studies in Income and Wealth, Vol. XXXI, *The Theory and Empirical Analysis of Production* (New York: Columbia University Press, 1967), pp. 200–3.

[6] This shift variable was used in this fashion by Murray C. Kemp, *The Demand for Canadian Imports*, 1926–1955 (Toronto: University of Toronto Press, 1962), pp. 17–18.

[7] The data on which these regressions are based are in the Appendix to Sawyer, "Forecasting Industry Output and Imports in an Open Economy." An error occurs for industry 8 for 1958 in two tables. The correct figures are 0·645 (Table 23) and 1·561 (Table 24). The regression results are available in Working Paper 6817 of the Institute for the Quantitative Analysis of Social and Economic Policy of the University of Toronto.

[8] This variable was not available for the non-manufacturing industries.

[9] This variable was not included in equations for industries which the import controls were not designed to affect.

output of the twenty-three industries for which we had forecast the market share parameter, and forecasts were made of imports competitive with these industries. Three forecasts were made: (1) using the 1949 vector of market shares, (2) using the actual 1957 (or 1958) values for the market share, and (3) using the forecast values of the market share for 1957 (or 1958) derived from the regression equations. The root-mean-square forecast errors are shown in Table 1. Forecast (3) is somewhat better than forecast (1), but, as can be seen by comparing these forecasts with forecast (2) which uses the actual values for the forecast year, a large part of the forecast error appears to be due to changes in the matrix of technical coefficients or to errors in translating the aggregate final demand for specific categories of fiscal expenditure (such as personal expenditure on consumer durables) into final demand for commodity groups.

Although the market share equation used here seems to make some contribution to making forecasting with Type I input–output models workable, a limitation is the need to develop a forecast of the price ratio variable r_i. The foreign price (q_t) may be taken as exogenous to the assumption that it is determined abroad and a forecast of it (before tariffs, taxes, and transportation costs) might be obtainable from models of the exporting country. The domestic price (p_i) must, however, be forecast. The model presented in the next section makes a step towards developing a price forecast.

TABLE 1

ROOT-MEAN-SQUARE FORECAST ERRORS FROM A TYPE I INPUT-OUTPUT MODEL USING VARIOUS VECTORS OF MARKET SHARE PARAMETERS

(millions of 1949 dollars)

Market Share Parameters Used for Forecasts	Forecasts of Output of Resource and Manufacturing Industries		Forecasts of Competitive Imports by Industry Groups	
	1957	1958	1957	1958
Actual 1949 parameters	136·2	130·4	77·6	68·5
Actual parameters for the forecast year	125·2	111·7	29·3	21·0
Forecast parameters for the forecast year	133·8	118·3	55·3	35·8

2. DEMAND FUNCTIONS FOR COMPETITIVE IMPORTS

Type II input–output models assume that an exogenous forecast of competitive imports by commodity class is available. For this type of model, what is required is a demand function for competitive imports. We constructed for manufacturing industries a three-equation model consisting of a demand for domestic output function, a domestic supply function, and a demand for imports function.[10] The purpose of the domestic output demand and supply submodel

[10] The specification of the model owes much to the work of Kemp, *The Demand for Canadian Imports*; M. FG. Scott, *A Study of United Kingdom Imports* (Cambridge: At the University Press, 1963); and Ronald A. Shearer, *Monetary Policy and the Current Account of Balance of International Payments* (Ottawa: Queen's Printer for the Royal Commission on Banking and Finance, 1962).

was to explain domestic price which appears as a variable in the import demand function.[11] Inventory change was included in the quantity of domestic output demanded, including any undesired inventory accumulation (as is usually done in the final demand vectors for input–output models). Thus, the equality between quantity demanded and quantity supplied determines a realized price which is not necessarily an equilibrium price. We assumed that the price of imports is determined on world markets and that the Canadian demand is a small proportion of total demand for these commodities so that the Canadian market faced a fixed price for imports.[12]

The principal determinants of the quantity demanded of both domestically-produced commodities and competitive imports for a particular industry, we hypothesized, are the price of domestic output of that industry, the price of imports competitive with that industry,[13] and the level of final expenditure for the components of gross national product most closely related to the output of that industry. We chose to enter as separate variables in the demand functions the price of domestic output relative to a general price level and the price of imports relative to a general price level. This implies an assumption of money illusion. Other explanatory variables introduced into the demand for imports equation were the excess capacity variable and the dummy shift variable which were used in the explanation of the market share parameter.

The industry supply equation contains three variables. The first is the average wage and salary bill in that industry per unit of constant dollar output (expressed as an index, 1949 = 100). This variable is introduced as an indicator of the costs of production. The second is the net stock of fixed capital,[14] a proxy for a capacity variable. The third is the price of the products of the industry group, since economic theory tells us that an increase in the product price should evoke an increase in any quantity supplied, other things equal.

Our model then takes the following form. The industry subscript for each of the seventeen manufacturing industry groups has been suppressed as has the time subscript identifying each observation.

[11] The assumption of pure competition which is implicit in the specification of an aggregate supply function for Canadian industries may be inappropriate in light of the oligopolistic nature of some industries. Some experiments with price determination equations for Canadian exports are reported on in J. A. Sawyer, "Foreign Trade in the TRACE Model," a paper presented to a meeting of Project LINK at the London Graduate School of Business Studies, September, 1970.

[12] In a study using broad categories of imports similar to ours, Kemp noted that "there is not a single instance in which Canada takes more than ten per cent of its supplier's total output. It follows that the Canadian import supply functions must be highly elastic," Kemp, *The Demand for Canadian Imports*, p. 12.

[13] The price index of output is an implicit price index which, because of the changing weights, is not well-suited for measuring year-to-year change. It was, however, the only index available for the period. Since 1956 an index of selling prices for manufacturing industries is available. See Dominion Bureau of Statistics, *Industry Selling Price Indexes*, 1956–1959 (Publication No. 62-515; Ottawa: Queen's Printer, 1961). The price indexes of competitive imports are base-period weighted indexes. The output indexes are f.o.b. the producing establishment and the import indexes are c.i.f. the border, including customs import duties. Both indexes exclude sales and excise duties levied after the final stage of processing has been completed.

[14] Dominion Bureau of Statistics, *Estimates of Fixed Capital Flows and Stocks, Manufacturing, 1926–1960*. This statistic is available for the same thirteen groups of manufacturing industries as the excess capacity variable and the same procedure was followed to match these with our seventeen groups as was described in the previous section.

(2) $$x_d = \beta_0 + \beta_1 f_i + \beta_2 q + \beta_3 p + u_1$$

(3) $$x_s = \delta_0 + \delta_1 w + \delta_2 k + \delta_3 p + u_2$$

(4) $$x_d = x_s$$

(5) $$y = \gamma_0 + \gamma_1 q + \gamma_2 c + \gamma_3 f_i + \gamma_4 s + \gamma_5 p + u_3$$

where

x is the output of the industry in millions of 1949 dollars. The subscript d identifies the demand function and the subscript s identifies the supply function.

y is competitive imports for that industry in millions of 1949 dollars.

p is the deflated implicit price index of industry output, f.o.b. the producing establishment (1949 = 100).

q is the deflated price index of competitive imports, c.i.f. the border, including customs import duties (1949 = 100).

w is the deflated wage and salary bill per unit of constant dollar output (1949 = 100).

k is the net stock of capital in the industry at the middle of the year in 1949 dollars.

c is the potential output of the industry less the actual output in 1949 dollars (excess capacity).

s is a dummy variable which takes on the value of 1.0 in 1948, 0.5 in 1949, and zero in all other years.

f_i is a final expenditure total where the subscript i has the following values and meaning (measured in millions of 1949 dollars):

1. personal expenditure on consumer durable goods
2. personal expenditure on consumer nondurable goods
3. personal expenditure on consumer services
4. exports of goods and services
5. gross domestic product at market prices less exports of goods and services
6. gross domestic product at market prices
7. business gross fixed capital formation in construction
8. personal expenditures on consumer durables plus business gross fixed capital formation in machinery and equipment
9. f_8 plus exports of goods and services
10. personal expenditure on consumer durables plus business gross fixed capital formation in construction
11. f_{10} plus exports of goods and services

u_i is an independently distributed random disturbance with zero expectation and constant variance.

The model is linear in the original values of the variables. Alternatively, a multiplicative model might have been specified in which the coefficients are elasticities.

Equations (2)–(4) are a set of simultaneous equations which can be solved for the level of domestic output, x, and the domestic output price, p. The variables

f, q, w, and k are regarded as predetermined variables.[15] The level of imports, y, can be obtained by substituting the value of p obtained from equations (2)–(4) into equation (5) along with the values of the predetermined variables q, c, f, and s.

Parameters of equations (2) and (3) were estimated by two-stage least squares.[16,17] Equation (5) was estimated by direct least squares on the assumption that the disturbance in the import demand equation (5) was not correlated with the disturbances in the other structural equations (2) and (3) and despite the presence of the price of domestic output as a regressor in the equation.[18] The use of direct least squares also involved the assumption that the covariance between q and u_3 and between p and u_3 are both zero.[19] Data for the period 1947–1956 were used to estimate the parameters.

The seventeen manufacturing industries were divided into consumers goods manufacturing industries and producers goods manufacturing industries. For the consumer goods industries, it seemed desirable to express demand on a per person basis. Accordingly, the variables x, y, f, and k were divided by the population.[20] For the producers goods industries the variables were not transformed to a per person basis. Different price deflators were used for the two sets of manufacturing industries. Product and import prices for the consumers goods industries were deflated by the consumer price index, while producers goods prices were deflated by the wholesale price index.

For the resource industries, it was assumed that the price of the product is determined on world markets. There will exist, however, some difference between import and domestic prices because of customs import duties, foreign exchange rates, and transportation costs. The specification of the demand equations therefore included domestic and imported price as separate variables. Our assumption that prices are predetermined means that direct least squares could be appropriately used to estimate the parameters of the equations. Since

[15] It was assumed that the covariances of these variables with the u_i were negligible.

[16] The variable c is a quasi-endogenous variable since it implicitly includes x. Although it was treated as an exogenous variable in equation (5), it was excluded from the first stage of the 2SLS regressions. If the specification of equations (2) and (3) is correct, the 2SLS estimates should be superior to those from the application of least squares to the reduced form equation for domestic price. Forecasting experiments showed little difference between the mean square forecast error of the two estimators.

[17] We have ignored the bias of errors of observation. Such errors are undoubtedly present in our price indexes, and are also likely present in the quantity variables. The same price indexes have been used as both regressors and deflators of the quantity variables; thus the error in the quantity figure is highly and negatively correlated with the error in the price index. Kemp demonstrates that under such conditions the bias in the estimates of price elasticities is towards unity, *The Demand for Canadian Imports*, pp. 15–16 and 64–67.

[18] Objection can be made to this assumption on the grounds that since both equations (2) and (5) are demand functions for similar commodities, the effects of variables implicitly included in the disturbances of both equations, such as advertising, will move together.

[19] Kemp shows that a sufficient condition for the assumption that the covariance between q and u_3 is zero is that the shifts of the import demand function are independent of the shifts of the import supply function. He demonstrates that, for Canada, this is a reasonable assumption, with the exception of his category of automobiles, trucks, and parts. For this class, which is a finer class than ours, he uses limited information methods of estimation. Kemp, *The Demand for Canadian Imports*, pp. 11–15.

[20] Kemp followed a similar procedure.

no estimates of capital stocks are available for nonmanufacturing industries, the excess capacity variable did not appear in the import demand equation. The price indexes are deflated by the wholesale price index.

Table 2 presents the root-mean-square error forecasts for industry output made in three ways. Method one is to use the regression model represented by equations (2)–(5). Method two is to use the Type II input–output model using the actual import figures for 1957 and 1958. Method one also produces forecasts of competitive imports whose results may be compared with those in Table 1.

TABLE 2

ROOT-MEAN-SQUARE FORECAST ERRORS FROM VARIOUS PREDICTORS FOR MANUFACTURING AND RESOURCE INDUSTRIES

(millions of 1949 dollars)

Predictor	Industry Output		Competitive Imports	
	1957	1958	1957	1958
(1) Demand and supply model, equations (2)–(5)	139·7	159·4	23·8	31·2
(2) Input-output (Type II) using actual y	164·1	136·8		
(3) Input-output (Type II) using forecast y from equation (5)	155·6	135·9		
(4) Input-output (Type II) updated to 1956, using actual y	25·5	54·1		

These comparisons are, however, unfair to input–output analysis since we are using 1949 coefficients. Research has established that these coefficients do not remain stable over time. The use of adjustment procedures is possible.[21] Let us use the simplest of adjustment procedures, a row-adjustment procedure, to adjust the matrix of technical coefficients A, to be consistent with 1956 marginal totals. Forecasts from this matrix are also shown in Table 2 so that the reader can see the "best" forecast from an input–output model.[22]

A further improvement in the input–output forecast can be made if "key" coefficients can be changed to take into account known changes such as those which occurred in Canada during the early 1950's. For example, there was a

[21] See K. J. Arrow and M. Hoffenberg, *A Time Series Analysis of Interindustry Demands;* T. I. Matuszewski, P. R. Pitts, and J. A. Sawyer, "L'adjustement périodique des systèmes de relations inter-industrielle, Canada, 1949–1958, *Econometrica*, XXXI (January–April, 1963), pp. 90–110; T. I. Matuszewski, P. R. Pitts, and J. A. Sawyer, "Linear Programming Estimates of Changes in Input Coefficients," *Canadian Journal of Economics and Political Science*, XXX (May, 1964), pp. 203–210; University of Cambridge, Department of Economics, *Input-Output Relationships*, 1954–1966 (London: Chapman and Hall, 1964); J. Paelinck and J. Waelbroeck, "Etude empirique sur l'évolution de coefficients 'input-output'," *Economie Appliqué*, XVI (1963), pp. 81–111; and Michael Bacharach, "Estimating Nonegative Matrices from Marginal Data," *International Economic Review*, VI (Sept., 1965), pp. 294–310.

[22] This forecast is presented in more detail in Sawyer, "Forecasting Industry Output and Imports, Some Experiments for Canada, 1950–1958," pp. 35–48.

substantial displacement of imported petroleum by newly-discovered domestic petroleum, natural gas replaced manufactured gas, and synthetic fibres came into competition with natural fibre.[23] It may be simpler to allow for such substitutions in an input–output matrix than in a demand and supply model which contains only a few parameters.

We conclude, therefore, that if adjustment techniques are used to "update" the input–output matrix, the input–output matrix gives the best forecast of industry output. The purpose of our study was not, however, to demonstrate this but to examine the workability of input–output analysis. The forecast of industry shown in line (1) was incidental to our forecast of domestic industry output. The results shown in the third line of Table 2 show that there is little difference between using the forecast values of competitive imports and the actual values. Thus, it appears feasible to use a Type II input–output model, which treats imports as exogeneous, if the procedure suggested in this paper can be followed.

We have demonstrated that it is feasible to make the import forecasts necessary to either of the input–output models discussed here. Although our forecasting models are simple and might be substantially improved, the forecasts of market shares or import levels are better than using base-period values. A question remains as to which input–output model gives better industry output forecasts. A comparison of Tables 1 and 2 suggests the Type I model, the market share model, is better,[24] although the evidence of the single set of experiments is not conclusive.

[23] Such direct adjustments to coefficients were made by T. I. Matuszewski, P. R. Pitts, and J. A. Sawyer, "The Impact of Foreign Trade on Canadian Industries, 1956," *Canadian Journal of Economics and Political Science*, XXXI (May, 1965), pp. 220.

[24] This conclusion is examined at greater depth in Sawyer, "Forecasting Industry Output and Imports: Some Experiments for Canada."