# International Transmission of Economic Fluctuations and Inflation

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This paper is concerned with the international transmission of fluctuations in prices, income and employment. A satisfactory model of the transmission mechanism must embody the income, price and monetary channels by which a disturbance in one country may be propagated abroad. The main channels have been exhaustively analyzed in the literature on balance-of-payments adjustment. Simple two-country models may be used to isolate the effects of induced changes in money stocks and price levels to restore external balance when full employment and fixed exchange rates are assumed. Correspondingly rudimentary Keynesian models may be used to derive static or dynamic income multiplier responses to disturbances originating at home or abroad under conditions of fixed prices and interest rates. Price and income determinants have been considered together particularly in the synthesis of the elasticity and absorption approaches to the analysis of devaluation. An excellent survey of these simplified models may be found in Stern (1973) and there is no point in replicating them here. What can be done with profit is to (a) specify the structural features that should be included in a realistic multinational model of the transmission mechanism for forecasting and policy analysis and (b) present quantitative estimates of international multipliers.

When writing on this subject in 1962, Polak and Rhomberg lamented the lack of national econometric models that could be hooked together into a world model by linking their international trade connections. Since that time an efflorescence of national econometric models has occurred, and many of the best of these have been welded together in a functioning world model under the auspices of Project LINK. The first part of this paper is devoted to a description of the LINK system as it existed in early

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1974 and to an examination of its multiplier properties for the light they may cast on the quantitative aspect of the contemporary transmission mechanism. A concluding section summarizes some alternative theoretical approaches to the analysis of world-wide inflation in relation to the present properties and projected improvements in the LINK system.

In its international aspects the LINK system may be regarded as a generalization and empirical implementation of Metzler's 1950 model of a multiplier region theory of income and trade. Earlier econometric treatments include the models of Beckerman (1956), Polak and Rhomberg (1962) and Morishima and Murata (1972). In comparison with these forerunners, Project LINK features greater geographical detail and a richer collection of constituent national models, especially as concerns sectoral disaggregation and lag structures. As we shall see, the system also differs from its predecessors in the use of a trade matrix instead of bilateral import functions for the international linkage.

## The LINK System

At the time of writing, 31 nations or regions are distinguished in the system. Full-blown structural models are included for the following 12 developed market economies: Australia, Austria, Belgium, Canada, France, West Germany, Italy, Japan, The Netherlands, Sweden, United Kingdom, United States of America.[1] Thirteen other developed economies are represented merely by reduced form equations for import quantities and export prices: Denmark, Finland, Greece, Iceland, Ireland, New Zealand, Norway, Portugal, South Africa, Spain, Switzerland, Turkey, and Yugoslavia.[2] The less developed countries (LDCs) are represented by four regional structural models for Africa, Asia, the Middle East, and Latin America.[3] The socialist economies are treated as a self-contained bloc in the world trade calculations, using essentially reduced form trade relationships, as are a few other countries in the "rest of the world."

[1]The models are built and maintained in the following institutions: Reserve Bank of Australia; Institute for Advanced Studies, Vienna; Free University of Brussels (for the Belgian and French models); Institute for the Quantitative Analysis of Social and Economic Policy, University of Toronto; University of Bonn; Instituto di Scienze Economische, University of Bologna; Institute of Economic Research, Kyoto University; Central Planning Bureau, The Hague; National Institute of Economic Research, Stockholm; Econometric Forecasting Unit, London Business School; Economics Research Unit, Wharton School of Finance and Commerce, University of Pennsylvania.

[2]The Bank of Finland has built a structural model for that country which has been added to the system since the simulations reported herein were prepared.

[3]These models were built at the Secretariat of the United Nations Conference on Trade and Development. At the time of writing, the UNCTAD group had completed a number of new LDC models for early incorporation in the LINK system. These include models for Argentina, Brazil, Mexico, the Andean countries, and the rest of Latin America; for India, Ceylon, Bangladesh and Pakistan, Korea, Malaysia, the Phillipines, and the rest of Asia; and for the oil and non-oil regions of the Middle East.



The 12 structural models for developed market economies are the backbone of the LINK system.[4] They are large, disaggregated, demand-oriented dynamic models of Keynesian persuasion. Output in each national model is proximately determined by real effective demand, and most of the models include distributed lag functions for consumer expenditures, business fixed investment, residential construction, inventory investment, imports and exports. In most of the models, inverted short-run production functions, which may or may not incorporate capital stock explicitly, are used to determine employment as a function of output. Wages are usually explained by some version of the Phillips curve, whereas domestic prices are directly determined as a mark-up on unit labor-cost, often with an allowance for varying demand pressures as reflected in an unemployment or utilization rate. With two exceptions (Australia and Germany), import prices are also a direct determinant of domestic prices in the models, since they appear as arguments in some or all of the price equations.

The monetary sectors of the various national models are also specified along Keynesian lines. Investment expenditures, consumption expenditures, or both, are a function of interest rates in most of the models, and several of them include liquid assets in the expenditure functions as well. Because of the importance of monetary policy as an instrument of economic stabilization, and because the money supplies of the various nations may be linked through the balance of payments, it has been agreed that the LINK models should have monetary sectors to determine the money stock and interest rates as endogenous variables unless one or both are exogenous policy instruments. This is true only for Italy, the United Kingdom and the United States in the simulations reported below, however. Bank deposits are endogenous in the Australian and Dutch models but interest rates are not, whereas the reverse is true of the models for Canada and Japan. Both interest rates and money stocks are exogenous in the remaining models. Complete monetary sectors have recently been developed for the Austrian, German and U.K. models but they have not yet been programmed into the LINK system.

With regard to the balance of payments, the national models currently included in the LINK system explain merchandise and service flows, but not capital movements. Work is progressing rapidly in the latter area, however, and complete models of the balance of payments have recently been developed for Canada, Germany, Japan, the United Kingdom and the United States, and soon will be programmed into the system. Meanwhile, simulations with the present system must be evaluated without monetary feedbacks from payments imbalances with other countries.

Prices and quantities of merchandise imports and exports therefore provide the principal connections between the national models in the

[4]The characteristics of most of these models are described and compared in articles by Ball (1973b) and Waelbroeck (1973a).

LINK system as presently constituted.[5] The typical import equation in a national model is[6]

$$m_{ik} = m_{ik}(y_i, p_{ik}, p^m_{ik}, r_i, z_i) \quad (1)$$

where $m_{ik}$ is the real quantity of imports of commodity k into country i, measured in local currency units; $y_i$ is a real activity variable for country i, such as gross domestic product or industrial production; $p_{ik}$ is the domestic price index of close substitutes for commodity k; $p^m_{ik}$ the import price index of commodity k in U.S. dollars; $r_i$ is the exchange rate of local currency in terms of U.S. dollars; and $z_i$ are other variables affecting imports, possibly including lagged values of the dependent or independent variables.

Equation (1) is a structural demand function for imports and is homogeneous of degree zero in prices and incomes in accord with the classical assumption of absence of money illusion. Imports are assumed in infinitely elastic supply, so $p^m_{ik}$ is exogenous to each national model. Close but not perfect substitution is assumed between domestic and imported goods, so the quantity of imports depends on relative prices as shown. The exchange rate $r_i$ is an exogenous parameter, permitting simulations of the effects of devaluations or revaluations on trade flows between countries.[7] All the national models in LINK contain import demand functions for four commodity classes: food and agricultural products (SITC 0+1), raw materials (SITC 2+4), fuel and lubricants (SITC 3) and manufactured products (SITC 5-9).

On the side of exports, one approach would be to obtain the exports of one country from the import demand functions of the other countries. This would be possible for a small system of, say, three of four regional models,[8] but it is impracticable on the scale of the LINK system, since n(n-1) bilateral import demand functions would be needed for each of the m commodities distinguished in a n-country model, and in principle each demand function would depend on mn prices.[9]

As a result of these considerations, it was decided to develop the export demand functions in LINK by a two-step procedure using a utility-tree approach.[10] At the first step, total imports of a given commodity class

[5]See Sawyer (1973), for a discussion of the treatment of invisibles on current account in the LINK system.

[6]For a detailed discussion of the commodity trade equations of the LINK system, see Basevi (1973).

[7]See Moriguchi (1973) for an example relating to the Smithsonian currency realignments in 1971-72.

[8]As an example of such a system, see Polak and Rhomberg (1962).

[9]Cf. Rhomberg (1973).

[10]The basic theoretical structure is set forth in Hickman (1973). It is a modification and generalization of Armington's 1969 trade model.



are determined by the import demand function (1). The quantity of imports so determined is then allocated among the supplying countries by estimated market shares. Let $x_{ijk}$ be the exports of country i to country j for the kth commodity class. Then the total imports of the commodity by country j are $m_{jk} = \Sigma_i x_{ijk}$, and the market shares are $\alpha_{ijk} = x_{ijk}/m_{jk}$. Given the $\alpha$ coefficients and the predetermined import quantities, the exports of country i are:

$$x_{ik} = \sum_j x_{ijk} = \sum_j \alpha_{ijk} m_{jk}.$$

The share coefficients do not remain constant from period to period, however, and in the LINK model the current shares are a function of relative export prices and time. Thus the export demand function for country i and commodity k is

$$x_{ik} = x_{ik}(\alpha^o_{i1k} \ldots \alpha^o_{ink}, p^x_{ik}, p^{xc}_{ik}, t, m_{1k} \ldots m_{nk}) \quad (2)$$

In this expression the $\alpha^o_{ijk}$ are base period market shares, $p^x_{ik}$ is the export price of commodity k from country i, and $p^{xc}_{ik}$ is a weighted index of competing countries' export prices as faced by country i.[11]

The trade system is completed by two sets of price equations for exports and imports. The export prices are endogenously determined in each national model. If perfect competition were assumed, they would be ordinary supply functions normalized on price, but in the LINK models they are more apt to be price mark-up equations. Prices of competing exports sometimes appear as explanatory variables, and other variables appearing in various combinations in the several models include labor costs, raw material prices, and utilization indexes.[12] At present, export prices are disaggregated in only a few of the LINK models, but separate price equations are under development for each model on the same SITC breakdown as used in the import side.

The import price indexes are weighted averages of the export prices, with weights given by the same market share coefficients used to allocate import quantities:

$$p^m_{jk} = \sum_i \alpha_{ijk} p^x_{ik}.$$

[11]See Hickman (1973) for the theoretical derivation of the weights for $P^{xc}_{ik}$. Alternative formulations of equation (2) are discussed in Klein et al (1972), Moriguchi (1973), and Hickman and Lau (1973). The complete version of equation (2) was used only for manufactured products in the simulations reported below. The current-price market shares were held constant for the other commodity groups, which amounts to assuming a unitary elasticity of substitution with respect to changes in relative export prices.

[12]See Basevi (1973), pp. 269-73.

The four regional models for developing countries (Africa, Asia, Middle East, and Latin America) are designed to bring out the essential features which distinguish the developing countries from the industrialized ones.[13] First, real GDP is supply-determined in the Asian and Latin American models because constraints from imported capital goods and raw materials are assumed to be binding. Second, apart from the Middle East model, the import functions differ from those of industrialized countries because they include the level of foreign exchange reserves as a restraint on import demand. Exchange reserves are endogenous in the African model but exogenous for Asia and Latin America. Third, the LDC models differ in their treatment of money and prices. Domestic prices are determined by capacity utilization, import prices, and the ratio of money stock to GNP, with export prices in turn a function of the domestic price level and export volume. The money stock is exogenous and interest rates are excluded from the models. This approach to price determination is not entirely along quantity-theory lines, however, since the liquidity ratio is only one argument in the price equations and there is no explicit demand function for money in the models.

As mentioned earlier, the remaining industrialized countries and the socialist economies figure in the world trade solutions through reduced-form trade equations, but the absence of structural models precludes measurement of multiplier effects on GNP and prices for those areas. Multipliers may be calculated for the regional LDC models, but none are presented herein because of the absence of country detail and because the models were structured for forecasting purposes rather than simulation exercises.

Details of the solution algorithm for the entire world system of linked national and regional models are to be found in several publications, and will not be discussed here.[14] It is sufficient to note that for a given set of domestic predetermined variables in the several national models and a given set of exchange rates, the system can be solved for all endogenous variables including a consistent set of trade flows and export and import price indexes, and satisfying the world trade constraint that $\sum_i x_i = \sum_i m_i$ as well as all domestic constraints.

It is apparent that the LINK system provides a number of channels for the international propagation of disturbances originating in a particular country. An exogenous change in domestic expenditure, for example, will affect domestic incomes and prices, which in turn will affect incomes and prices abroad directly by changing the export demands and import prices of other countries and indirectly by the consequential induced movements of incomes and prices in those countries. The price

[13] See Ball (1973a), Ch. 6, especially pp. 170-76.

[14] A sampling includes Klein and van Peeterssen (1973), Waelbroeck (1973b), and Moriguchi (1973).



linkages include direct effects — prices of imported materials are determinants of domestic prices in many of the models — as well as indirect connections via the influence of aggregate demand on wages and prices through the wage and mark-up equations. The magnitude of the induced responses at home and abroad will depend on the various elasticities and propensities in the models and cannot be inferred analytically in such a large and interdependent system. They can be estimated numerically by multiplier techniques, however, and some simulations of the system are presented and discussed in the next section.

## The International Income Multipliers

Own and cross-country income multipliers for many of the countries included in the LINK system ar presented in this section. These are dynamic multipliers for a three-year span. They are computed as follows. A dynamic control solution is calculated first for the entire linked system. Exogenous expenditures are then increased in country A and maintained at the higher level over the same three-year interval, and a new solution obtained. The induced changes in incomes and prices in all countries are then calculated as the difference between the control and shocked solutions. The procedure is repeated with separate shocks in countries B, C, . . ., in order to provide a matrix of own- and cross-country multipliers for each of the three years. These are standard procedures for non-linear models in which an explicit reduced-form solution does not exist. Like all non-linear multipliers, the numerical results may differ according to the initial conditions and the magnitude of the shocks. The present set is based on a control solution for 1973-1975.

Multipliers are usually presented as marginal responses per dollar of increase of autonomous expenditure. Thus, in the case of impact of single-period multipliers, one might calculate:

$$k_{ij} = \frac{\Delta Y_j}{\Delta A_i}, \tag{4}$$

where $\Delta A_i$ is the autonomous expenditure change in country i, $\Delta Y_j$ is the induced income response in country j, and the own-country multipliers obtain when $i = j$. This formulation does not allow for differences in size among the various countries, however. It measures the absolute income change in j induced per unit of expenditure change in i, but it does not indicate whether the income increment in j is large or small in relation to j's income level. A preferable measure is given by the elasticity multipliers:

$$K_{ij} = \frac{\Delta Y_j}{Y_j} \Big/ \frac{\Delta Y_i}{Y_i}, \tag{5}$$

where $\Delta \overline{Y}_i = \Delta A_i$ is the autonomous income change in country i. Expression (5) gives the percentage change in the income of country j induced by a given autonomous percentage change of income in country i. When i = j, (5) reduces to (4), so that the own-country absolute and elasticity multipliers have the same value. When i ≠ j, however, we see that

$$K_{ij} = \frac{\Delta Y_j}{\Delta \overline{Y}_i} \cdot \frac{Y_i}{Y_j} = k_{ij}\, y_{ij}\,, \qquad (6)$$

where $y_{ij}$ is the ratio of incomes in countries i and j. Thus the cross-country elasticity multipliers are larger or smaller than the absolute cross-country multipliers according to whether income in the disturbing country is greater or smaller than in the disturbed country. An apparently small multiplier in absolute terms may actually imply a substantial relative income change when a small country is disturbed by a shock from a large country, and vice versa.[15]

A shock of 10 to 15 percent of GNP or GDP was employed in all simulations except for Canada and the United States, for which 1 percent was used.[16] Wherever possible the shock was applied to government expenditure, but in a few cases, another component of aggregate demand was perturbed. For Austria, Canada, Germany, Italy and the United States the shock was applied to current dollar expenditure, and for other countries, to real expenditure. In the former cases, the income multipliers were converted to constant prices for greater comparability with the other models. These are particular examples of a general problem in comparing simulations for different models, since it is seldom possible to impose a completely uniform set of shocks on models with differing structural specifications.

The multiplier estimates may also be sensitive to the lack of uniformity in the monetary sectors of the models. For the models with endogenous interest rates (Canada, Italy, Japan, the United Kingdom and

[15]Elasticity multipliers could also be defined with respect to the percentage change in autonomous expenditure itself:

$$\frac{\dfrac{\Delta Y_j}{Y_j}}{\dfrac{\Delta A_i}{A_i}} = k_{ij}\, a_{ij}$$

where $a_{ij}$ is the ratio of autonomous expenditure in country i to income in country j. The formulation in the text is preferable in that it standardizes the autonomous shock according to the size of GNP and is not affected by differences among countries in the shares of autonomous expenditures in GNP.

[16]Shocks of 10 percent for Canada and the United States were too large to yield usable solutions.



the United States), the own-country multipliers implicitly assume the absence of an accommodating monetary policy to keep interest rates constant as government expenditures are incremented, so that some "crowding out" of private investment or consumption expenditure will mitigate income expansion, whereas this is not true of the models with exogenous interest rates. Similarly, the cross-country multipliers will be affected by these differences insofar as both the magnitudes of external impulses from differing countries, and their own response mechanisms, are modified by monetary influences.

No multipliers may be presented for the Netherlands model, owing to technical programming difficulties. The own-country dynamic income multipliers for the 11 remaining models are presented in Table 1. The impact multipliers range between zero and two.[17] Apart from the models for

## Table 1

### Elasticity Multipliers for Income, Own-Country, Three Years

(Percentage income change per unit percentage income shock in same country)

| Country | First Year | Second Year | Third Year |
|---|---|---|---|
| Austria | .79 | 1.14 | 1.86 |
| Belgium | 1.10 | .98 | .86 |
| France | 1.21 | 1.19 | 1.22 |
| Germany | .98 | 1.38 | 1.20 |
| Italy | 1.30 | 1.51 | 1.80 |
| Sweden | 1.12 | 1.12 | 1.12 |
| United Kingdom | 1.24 | 1.69 | 1.51 |
| United States | 1.18 | 1.87 | 2.58 |
| Canada | 1.15 | 1.15 | .79 |
| Japan | 1.18 | 1.50 | 1.50 |
| Australia | .79 | .71 | 1.03 |

[17]These impact multipliers include feedback effects from other countries. A separate calculation excluding the international feedback linkages yields virtually the same values: Austria, .75; Belgium, 1.10; France, 1.20; Germany, .94; Italy, 1.29; Sweden, 1.09; United Kingdom, 1.17; United States, 1.19; Canada, 1.08; Japan, 1.12; and Australia, .79. Insofar as own-multipliers are concerned, therefore, induced feedbacks from abroad may safely be ignored in individual national models, as concluded earlier by Morishima and Murata (1972).

France and Sweden, the multipliers change over time in dynamic simulations owing to lagged responses in the behavioral equations. The typical pattern shows rising income multipliers over the three-year horizon (Austria, Italy, United States, Japan). The multipliers for Belgium and Canada decrease over time, however, whereas those for Germany, the United Kingdom and Australia oscillate.[18]

The full multiplier matrices for three years are presented in Tables 2-4. These tables contain a wealth of detail that can only be extracted by close inspection on the reader's part. Some general observations and conclusions may be offered, however.

The own-multipliers from Table 1 are reproduced on the main diagonals of the new tables for convenient comparison with the cross-country effects. The cross-country impact multipliers are much smaller, with many values close to zero. A cross-country value of .1 is in an important sense as large as an own-country multiplier of 1.1, however, since the latter includes an autonomous income shock of 1 percent which is excluded from the former. Viewed this way, many of the cross-country multipliers imply a substantial induced income response to disturbances from abroad. Again it is found that the cross-multipliers vary over time as lagged effects work through the system.

The magnitude of the cross-country effects is partly determined by the trade relationships connecting each pair of countries. A country with a high marginal propensity to import and an inelastic supply of exports will transmit large shocks abroad. Its trading partners will receive these shocks in proportion to their importance as suppliers of its imports and demanders of its exports. Thus one expects to find relatively large cross-multipliers between countries with close trade ties, as between Germany and its European trading partners and between Canada and the United States. The cross-multipliers are also affected by the own-multipliers of the initiating and receiving countries, however, and these are dependent on internal as well as external leakages. One may mentally control this effect in scanning Tables 2-4 by dividing the cross-multipliers in a given row by the own-multiplier for that row. The resulting normalized cross-multipliers will more nearly isolate the basic trade relations among the various countries.

Another factor influencing the cross-elasticity multipliers is the relative size of the two countries in question. Thus, despite its low absolute import propensity, the United States has a fairly substantial impact on

[18]Government expenditure is partly endogenous in the German model, owing to lagged terms for induced increases in tax revenues and the rate of change of GNP. If the endogenous increments in government expenditure are included, the multipliers for the second and third years become respectively 1.75 and 1.94. The values in Table 1 are corrected for the induced increase in government expenditure for greater comparability with other countries. A similar correction was made for induced government spending in the Austrian model.

## Table 2

### International Elasticity Multipliers for Income, First Year

(Percentage income change of country in column induced per unit percentage income shock of country in row)

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | .79 | .01 | .01 | .03 | .02 | .03 | .02 | .00 | .00 | .00 | .00 |
| Belgium | .01 | 1.10 | .01 | .01 | .01 | .01 | .01 | .00 | .00 | .00 | .00 |
| France | .03 | .08 | 1.21 | .04 | .07 | .06 | .04 | .01 | .02 | .01 | .01 |
| Germany | .16 | .18 | .08 | .98 | .19 | .17 | .10 | .04 | .05 | .04 | .03 |
| Italy | .04 | .03 | .02 | .02 | 1.30 | .04 | .03 | .01 | .02 | .01 | .01 |
| Sweden | .01 | .01 | .00 | .01 | .01 | 1.12 | .01 | .00 | .00 | .00 | .00 |
| United Kingdom | .02 | .03 | .01 | .02 | .03 | .09 | 1.24 | .01 | .03 | .01 | .02 |
| United States | .05 | .05 | .02 | .04 | .08 | .10 | .08 | 1.18 | .31 | .13 | .03 |
| Canada | .03 | .02 | .01 | .02 | .03 | .05 | .05 | .08 | 1.15 | .02 | .02 |
| Japan | .01 | .01 | .00 | .01 | .01 | .02 | .02 | .02 | .02 | 1.18 | .04 |
| Australia | .01 | .01 | .00 | .01 | .01 | .02 | .03 | .01 | .01 | .02 | .79 |

## Table 3

### International Elasticity Multipliers for Income, Second Year

(Percentage income change of country in column induced per unit percentage income shock of country in row)

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 1.14 | .02 | .01 | .03 | .04 | .04 | .03 | .01 | .01 | .01 | .01 |
| Belgium | .01 | .98 | .01 | .01 | .02 | .02 | .02 | .01 | .01 | .01 | .00 |
| France | .03 | .07 | 1.19 | .05 | .08 | .05 | .05 | .02 | .01 | .01 | .01 |
| Germany | .39 | .35 | .16 | 1.38 | .42 | .35 | .25 | .11 | .10 | .09 | .07 |
| Italy | .07 | .04 | .03 | .03 | 1.51 | .06 | .06 | .03 | .02 | .02 | .02 |
| Sweden | .02 | .01 | .00 | .01 | .01 | 1.12 | .02 | .01 | .01 | .01 | .00 |
| United Kingdom | .06 | .05 | .02 | .03 | .06 | .14 | 1.69 | .04 | .06 | .03 | .04 |
| United States | .11 | .09 | .04 | .08 | .17 | .19 | .21 | 1.87 | .56 | .27 | .09 |
| Canada | .05 | .02 | .01 | .03 | .05 | .07 | .09 | .12 | 1.15 | .05 | .04 |
| Japan | .02 | .02 | .01 | .01 | .02 | .04 | .04 | .04 | .04 | 1.50 | .08 |
| Australia | .02 | .01 | .01 | .01 | .02 | .03 | .05 | .02 | .02 | .03 | .71 |



## Table 4

### International Elasticity Multipliers for Income, Third Year

(Percentage income change of country in column induced per unit percentage income shock of country in row)

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 1.86 | .03 | .02 | .06 | .07 | .07 | .05 | .02 | .01 | .01 | .01 |
| Belgium | .02 | .86 | .01 | .02 | .02 | .02 | .02 | .01 | .00 | .01 | .00 |
| France | .03 | .08 | 1.22 | .06 | .11 | .05 | .04 | .01 | .00 | .00 | .01 |
| Germany | .78 | .66 | .21 | 1.20 | .81 | .73 | .53 | .26 | .35 | .18 | .24 |
| Italy | .12 | .05 | .04 | .05 | 1.80 | .09 | .08 | .05 | .03 | .03 | .04 |
| Sweden | .03 | .01 | .01 | .01 | .02 | 1.12 | .02 | .01 | .00 | .01 | .00 |
| United Kingdom | .09 | .05 | .02 | .04 | .08 | .14 | 1.51 | .05 | .05 | .03 | .06 |
| United States | .24 | .15 | .06 | .14 | .31 | .33 | .35 | 2.58 | .86 | .40 | .24 |
| Canada | .07 | .02 | .01 | .03 | .06 | .07 | .08 | .13 | .79 | .04 | .03 |
| Japan | .04 | .02 | .01 | .02 | .03 | .05 | .06 | .06 | .04 | 1.50 | .13 |
| Australia | .02 | .01 | .00 | .01 | .02 | .02 | .03 | .02 | .01 | .02 | 1.03 |

economies abroad owing to its large size. This contradicts the earlier finding of Morishima and Murata (1972), which, however, referred to absolute rather than elasticity multipliers and was based on a much smaller and simpler system of expenditure functions.[19] Note also that these empirical multipliers do not allow for the influence of U.S. deficits on the expansion of international monetary reserves, and hence exclude another potentially powerful propagation channel, as discussed below.

Disturbances originating in Germany would be strong and widely diffused. Other large European countries could have a substantial impact on their close neighbors.

Apart from the caveats expressed in earlier and later portions of this paper, it is important to remember that the multiplier simulations measure only the potential for the spread of disturbances from one country to another, and imply nothing about the origin or size of actual disturbances. It is true that a single country cannot have much impact on the rest of the world unless its cross-multipliers are substantial. Its foreign impact will also depend on the magnitude of its domestic disturbances, however, so that a well-managed economy in which private disturbances were quickly neutralized by policy, and in which disturbances originating in government actions were themselves unimportant, would not be a serious threat to world stability even if its external multipliers were large.

## Propagation of Inflationary Impulses

As discussed earlier, the LINK system as presently constituted contains channels by which prices as well as real incomes may be affected by disturbances originating at home or abroad. These include the effects of induced changes in aggregate demand on unemployment and wages and also on profit markups, plus the direct impact of increases in prices of imported goods and materials on domestic prices in most models. In order to measure the strength of these effects we turn to the same simulations as reported in the preceding section and compute elasticity multipliers for prices by dividing the induced percentage change in the price level of country j by the given autonomous percentage change of income in country i.

But what index should be used to measure the general price level for this purpose? Although the GNP deflator is the most general price index available for most economies, it may sometimes understate the impact of foreign developments on domestic prices. Thus, the identity for the deflator is:

[19]Only consumer expenditures and imports are endogenous in their system. Several of the other principal findings of Morishima and Murata are generally confirmed by the LINK results, however.



$$PGNP = \frac{PC(C) + PI(I) + PG(G) + PX(X) - PM(M)}{GNP} \quad (7)$$

with obvious symbols for quantities and prices.

The prices of final goods for domestic sale or export include the costs of imported materials or goods, which accordingly must be subtracted to avoid the inclusion of value added by foreign producers in the national product. This means that, *ceteris paribus*, an exogenous increase in import prices which was passed through to final goods prices without affecting domestic value added would leave the GNP deflator unchanged. This condition is unlikely to be met in practice, however, because of attempts to preserve profit margins as import prices rise. In the LINK models, these influences would be reflected in the coefficients of the import price terms of the equations explaining prices of final demand components.

Even if there were no direct effect of import prices on domestic value added, however, the GNP deflator could respond to foreign shocks in the general equilibrium context of this paper, for two important reasons. First, changes in consumer prices will induce wage increases in the models for Austria, France, the United States, Canada and Japan. Second, in the present simulations, the external shock to import prices will be accompanied by a simultaneous external shock to export demand, and the consequent expansion of real income will tend to raise domestic wages and prices independently of the exogenous import price increase.

All this means that the GNP deflator may rise either more or less than an index of prices of final goods under inflationary shocks from abroad, depending on the response mechanism as modelled. The elasticity multipliers for prices presented in the following tables are derived from the GNP deflators. However, some additional calculations were done for comparative purposes and are reported in Appendix A. They are based on the following deflator for final expenditures:[20]

$$P = \frac{PY(Y) + PM(M)}{Y + M} \quad (8)$$

Although calculated by formula (8), the new deflator is readily seen to equal

$$P = \frac{PC(C) + PI(I) + PG(G) + PX(X)}{C + I + G + X} \quad (9)$$

a weighted average of the components of final expenditures for domestic use and export. Since 9 of the 11 models allow for the direct effects of import price increases on one or more of the sectoral deflators in equation

[20]This form was suggested to me by Lawrence R. Klein.

(9), the calculations using the expenditure price index should reveal any substantial bias from using the GNP deflator as an index of inflation, although leaving open the possibility that the strength of the direct price linkages themselves may be underestimated in the models.

It is convenient to study the own-multipliers for the GNP deflators before considering the cross-effects. Table 5 reveals a wide disparity in the estimated sensitivity of prices to domestic expenditure shocks in the various national models. In two cases, prices actually fall in response to the simulated increase in autonomous demand. (1) In the French model the decline results from a decrease in unit labor cost owing to a low estimated elasticity of labor input with respect to output. Thus, even though wages increase in response to higher production and employment, prices fall because of the large induced improvement in labor productivity. (2) The straight-time money wage is exogenous in the forecasting version of the U. K. model used in these simulations, so that the impact effect of the real income increase is to reduce prices by raising output per man-hour. Overtime earnings increase in subsequent years, however, thereby raising unit labor costs and prices despite the fixed wage rate. At the time of writing, a new U. K. model has been substituted in the LINK system, but the calculations could not be redone for this paper. Among other new features, the revised model includes an endogenous wage equation, so that future simulations will incorporate induced wage-price interactions.

## Table 5

### Elasticity Multipliers for Prices, Own-Country, Three Years

(Percentage price change per unit percentage income shock in same country)

| Country | First Year | Second Year | Third Year |
|---|---|---|---|
| Austria | .20 | .39 | .75 |
| Belgium | .07 | .13 | .09 |
| France | -.08 | -.83 | -1.73 |
| Germany | 1.10 | 2.02 | 2.38 |
| Italy | .08 | .05 | .38 |
| Sweden | NA | NA | NA |
| United Kingdom | -.36 | -.12 | .63 |
| United States | .31 | .29 | .69 |
| Canada | .03 | .69 | 1.30 |
| Japan | .04 | .04 | .10 |
| Australia | .12 | .24 | .18 |



The largest price response to domestic expansionary shocks is found in the German model. The impact effect of demand on prices is small in the Canadian model, but it builds to a high value in the second and third years. The models for Belgium, Japan and Australia imply considerable price stability at the capacity levels assumed in the control solutions, whereas Austria, Italy (in the third year), and the United States occupy an intermediate position.

With regard to price changes induced by disturbances from abroad, it is apparent from Table 6 that they are usually negligible in the first year. They become somewhat larger in subsequent years, and in some cases assume substantial proportions, as in the special relationship of the U. S. and Canadian economies and several less spectacular examples. For two countries — Germany and Canada — the cross multipliers for prices are usually larger than for real incomes, just as was true of the own-multipliers for these models. Generally speaking, however, as modelled in the LINK system, the international propagation of price disturbances through trade channels is weaker than for real incomes. This conclusion is also supported by the results for the alternative price indexes in Appendix A.

Apart from the basic finding that price responses to external shocks are generally small, it will be noted that for some countries they are frequently or always negative. The negative response for the United Kingdom is due to the exogenous treatment of wage rates, as previously discussed. The reasons for other negative signs can be ascertained without a detailed investigation of the individual models and their response mechanisms, a task which cannot be undertaken here. However, one possibility — that the negative changes in the GNP deflators are due to the subtraction of import proceeds from final expenditures in equation (7) — is discussed in Appendix A, where it is shown to be an incomplete explanation of the observed behavior.

In conclusion, the foregoing simulations suggest that the observed worldwide inflation of recent years should not be attributed to the spread of demand impulses from one or two dominant countries via foreign trade in merchandise, since the cross-multipliers for prices are generally small. Transmission of cost-push inflation conceivably could be stronger, however, especially if the exogenous shock to wages or prices were accompanied by accommodating demand policies to prevent an induced fall in real income. Unfortunately, the present simulations cast little light on this question, since the observed price responses are normalized on income shocks and are heavily influenced by propagation through income-induced increases in export demands as well as by the concomitant increases in foreign trade prices.

Even the conclusion that the international propagation of inflation from demand impulses is generally weak, may be wholly or partly reversed by improvements now underway in the LINK system, including the incorporation of international capital flows and domestic monetary sectors and improved explanations of commodity prices and linkages. There

## Table 6

### International Elasticity Multipliers for Prices, First Year*

(Percentage price change of country in column induced per unit percentage income shock of country in row)

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | .20 | .00 | .00 | .03 | .00 | NA | .00 | .00 | .00 | .00 | .00 |
| Belgium | .00 | .07 | .00 | .02 | .00 | NA | .00 | .00 | .00 | .00 | .00 |
| France | .00 | -.01 | -.08 | .05 | -.01 | NA | -.01 | .00 | .00 | .00 | .00 |
| Germany | .02 | -.02 | .01 | 1.10 | -.03 | NA | -.02 | .01 | .00 | .00 | -.01 |
| Italy | .00 | .00 | .00 | .03 | .08 | NA | -.01 | .00 | .00 | .00 | .00 |
| Sweden | .00 | .00 | .00 | .01 | .00 | NA | -.01 | .00 | .00 | .00 | .00 |
| United Kingdom | .00 | .00 | .00 | .02 | -.01 | NA | -.36 | .00 | .00 | .00 | .00 |
| United States | .01 | .00 | .01 | .05 | -.01 | NA | .00 | .31 | .00 | -.02 | -.01 |
| Canada | .01 | .01 | .01 | .02 | .00 | NA | .00 | .01 | .03 | .01 | -.01 |
| Japan | .00 | .00 | .00 | .01 | .00 | NA | .00 | .00 | .00 | .04 | -.01 |
| Australia | .00 | .00 | .00 | .01 | .00 | NA | -.01 | .00 | .00 | .00 | .12 |

(*) Price index is implicit deflator for GNP or GDP.

NA — Not available.



## Table 7

### International Elasticity Multipliers for Prices, Second Year*

(Percentage price change of country in column induced per unit percentage income shock of country in row)

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | .39 | .00 | .00 | .05 | -.01 | NA | -.01 | .00 | .00 | .00 | .00 |
| Belgium | .00 | .13 | .00 | .02 | .00 | NA | -.01 | .00 | .00 | .00 | .00 |
| France | .00 | .01 | -.83 | .06 | -.01 | NA | -.01 | .00 | .01 | .00 | .00 |
| Germany | .04 | -0.5 | .00 | 2.02 | -.05 | NA | -.04 | .01 | .03 | -.01 | -.02 |
| Italy | .00 | .00 | -.01 | .05 | .05 | NA | -.01 | .00 | .01 | .00 | -.01 |
| Sweden | .00 | .00 | .00 | .02 | .00 | NA | -.01 | .00 | .00 | .00 | .00 |
| United Kingdom | .01 | -.01 | .00 | .06 | -.01 | NA | -.12 | .00 | .03 | .00 | -.02 |
| United States | .01 | -.01 | .00 | .11 | -.02 | NA | -.06 | .29 | .17 | -.03 | -.03 |
| Canada | .00 | .02 | .01 | .04 | .00 | NA | -.06 | .02 | .69 | .01 | -.02 |
| Japan | .00 | .00 | .00 | .02 | .00 | NA | -.01 | .00 | .01 | .04 | -.02 |
| Australia | .00 | .00 | .00 | .01 | .00 | NA | -.01 | .00 | .01 | .00 | .24 |

(*)Price index is implicit deflator for GNP or GDP.

NA — Not available.

## Table 8

### International Elasticity Multipliers for Prices, Third Year.*

(Percentage price change of country in column induced per unit percentage income shock of country in row)

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | .75 | .00 | .00 | .08 | .00 | NA | .00 | .00 | .03 | .00 | -.01 |
| Belgium | .00 | .09 | .00 | .03 | .00 | NA | .01 | .00 | .02 | .00 | .00 |
| France | .00 | .03 | -1.73 | .08 | .04 | NA | .02 | .01 | .02 | .00 | .00 |
| Germany | .14 | -.29 | .10 | 2.38 | -.14 | NA | -.05 | .03 | .10 | -.01 | -.10 |
| Italy | .02 | -.01 | -.01 | .09 | .38 | NA | .01 | .00 | .03 | .00 | -.01 |
| Sweden | .01 | .00 | .00 | .02 | .00 | NA | .01 | .00 | .01 | .00 | .00 |
| United Kingdom | .03 | -.01 | .01 | .11 | .01 | NA | .63 | .01 | .09 | .00 | -.04 |
| United States | .04 | -.01 | .02 | .23 | .01 | NA | .00 | .69 | .64 | -.03 | -.10 |
| Canada | .01 | .02 | .02 | .06 | .01 | NA | .00 | .04 | 1.30 | .01 | -.03 |
| Japan | .00 | -.01 | .00 | .03 | .00 | NA | .00 | .01 | .03 | .10 | -.03 |
| Australia | .00 | .00 | .00 | .02 | .00 | NA | .02 | .00 | .03 | .00 | .18 |

(*) Price index is implicit deflator for GNP or GDP.

NA — Not available.





is scope within the present system for at least a partial explanation of world-wide inflation owing to synchronization of disturbances across many countries, however, with induced trade flows serving to amplify and reinforce the common impulses.

In the first place, the own-country price multipliers are predominantly finite and positive, as we have seen. Thus domestic price levels do respond to demand stimuli in the LINK country models, and a set of synchronized demand shocks would generate synchronized price inflation in the various models. Synchronized autonomous shocks to the wage equations would also result in widespread price increases, although real incomes would probably fall if expansionary fiscal and monetary policies were not assumed as a complement to the cost-push from the wage side. In their paper "Stability in the International Economy: The LINK Experience," also included in this conference volume, Johnson and Klein report on several simulations with synchronized shocks and show how the effects are amplified in the linked solutions.

If world-wide price inflation is indeed due largely to synchronized impulses rather than transmission via trade flows or some other mechanism, two further questions must be asked. First, why should the shocks in the various countries be synchronized? Second, what assures the provision of sufficient additional liquidity to support the price increases?

Several plausible hypotheses may be advanced with regard to the synchronization of shocks, although it is beyond the scope of this paper to assess their likely importance or to test them empirically.

1. International political events may affect many countries simultaneously. Recent potent examples are the Vietnam War and the oil embargo and OPEC price increases.

2. The widespread political commitment to full employment in the industrialized economies implies a rather continuous use of expansionary fiscal and monetary policies in the several countries. To the extent that fluctuations in real income are synchronized by the international multiplier mechanism, so also will tend to be variations in the intensity of use of fiscal and monetary instruments to augment or diminish demand. Demand policy may be expected to be expansionary in most years, however, because of the full employment commitment.

3. Synchronization of wage and price increases in imperfect markets may result from the activities of international labor organizations and multinational corporations. Widespread attempts to implement incomes policies in the western democracies may have increased labor's relative income consciousness and augmented the tendency toward synchronization of cost-push pressures.

Whatever the degree and importance of synchronization of shocks from these and other sources, it remains true that their inflationary effects could be offset by restrictive monetary policies. If the money supply is expanded in the interests of full employment policy, either as a direct demand stimulus or to accommodate inflationary impulses from the private or foreign sectors, the liquidity is provided to sustain the higher price level. Even allowing for induced variations in income velocity, there is some degree of restraint on the money supply that would prevent the price level from rising. At bottom, then, the explanation for inflation rests on those motivations which determine the unwillingness of monetary authorities to curb inflation. These motivations include, but may not be restricted to, the unwillingness to augment unemployment and reduce real incomes in order to restrain prices.

## Alternative Approaches and Weak Links

The domestic challenge of Keynesian models by the monetarists has also spilled over into the international sector. According to Mundell and Johnson, for example, the world-wide inflation since 1965 is the consequence of excessive growth of the world money supply, which in turn is attributed to the chronic U.S. balance-of-payments deficit and the resulting growth of international dollar reserves.[21] That is to say, in this view, the United States was not subject to balance-of-payments discipline and the Federal Reserve could and did pursue an inflationary monetary policy which led the public to export the excess supply of money through the payments deficit.

Using a small general equilibrium model of an open economy in which markets for goods and services, bonds, and money are distinguished, it can be shown that the balance of payments is equal to the excess demand for (domestic) money less the amount of money created by the bond purchases of the banking sector. (Komiya, 1969) The counterpart to a positive excess demand for money must be an excess supply of goods, bonds, or both, leading to corresponding surpluses on current account, capital account, or both, and thereby enabling the private sector to acquire foreign exchange for conversion into the desired increment in domestic money balances. Conversely, if the monetary authority creates an excess supply of money, the result must be a balance-of-payments deficit at home and hence an inflationary flow of reserves into one or more surplus countries abroad. Frequently, money only is made to matter in these models by assuming continuous full employment and perfect world-wide markets for tradable goods and services and for capital, so that the individual country has no control over prices or interest rates and the only equilibrating mechanism affecting the balance of payments consists of the induced changes in the money supplies of deficit and surplus countries, which eventually restore portfolio balance at the fixed levels of prices and interest rates.

One need not accept the most extreme assumptions of the monetarists in order to agree that the monetary implications of external surpluses and deficits should be incorporated into any complete model of the transmission mechanism. Those LINK models which already include a monetary sector to determine the nominal money stock and interest rates generally assume that the central bank has control over the monetary base, so that an independent monetary policy may be pursued, if desired, by sterilizing the effects of inflows and outflows of international reserves on the domestic money supply. The capacity for sterilization is certainly finite, however, and it would be well to model the process by incorporating complete balance-of-payments sectors in the national models so as to allow explicitly for flows of international reserves and their effect on the monetary base and monetary policy. As mentioned above, it has been agreed among LINK participants to push ahead as rapidly as possible on the monetary and balance-of-payments sectors of the national models, but the LINK system as represented in the simulations reported herein is incomplete in these respects. In view of the contemporary importance of the Eurodollar market for international finance and interest rates, it will probably be necessary to model it as well as the domestic monetary sectors. Once all models have complete monetary and balance-of-payment sectors, multiplier simulations can readily be made for exogenous changes in the monetary base in order to test some of the monetarist assertions about monetary mismanagement as the fundamental cause of world inflation.

[21]See the panel discussion on world inflation in Claassen and Salin (1972), especially pp. 310-313 and 323-324, and also Johnson (1972), Ch. III.



With regard to external determinants of domestic inflation, three principal transmission channels have been discussed thus far: the direct impact of import prices on domestic prices, the indirect multiplier effects of export demands on domestic incomes and prices, and the indirect effects of reserve inflows on the money supply and hence on domestic incomes and prices. The "Scandinavian" model of imported inflation suggests a fourth channel involving export prices.

According to this model,[22] an economy is divided into an export sector which is competitive in world markets and a sheltered domestic sector which is not. Given a fixed exchange rate, prices in the export sector must follow the world export price level. Money wages in the export sector are then determined by export prices and by productivity growth in the export industries, assuming a bargaining mechanism for a constant wage share. The sheltered sector must match this rise in money wages to retain its labor force, but its prices rise even faster than in the export industries, owing to its generally slower rate of productivity growth. Hence the domestic price level is geared to that of internationally traded goods and services, but the domestic inflation rate is higher than the rate of inflation of tradable commodities.

With regard to the LINK system, the models for several countries — Italy, the Netherlands, Sweden and the United Kingdom — incorporate the first part of this mechanism, in the sense that the price of competing exports appears in their own export price equations. Wage rates are not, however, determined by prices and productivity in the export sector in

[22]This discussion is based on Edgren et al (1969), as summarized in Artis (1971).

these models. Presumably if future research validates the hypothesis for particular countries, it will be incorporated in the relevant models in the LINK system. The most likely candidates are small, highly open economies which are essentially price takers selling their basic commodities in competitive world markets, rather than the generality of industrial countries.[23]

The proposition that export prices are set in world markets is a basic ingredient of the "Scandinavian" model, as we have just seen. Presumably the proposition applies with greatest force to homogeneous commodities for which organized world markets exist, and for such commodities, world price determination has implications surpassing those stressed in the Scandinavian model itself.

By and large, export prices are internally determined in the national and regional models in the present LINK system. This is doubtless basically correct for manufactured goods, but it is certainly questionable for foods, fuels and raw materials. What is needed for price determination in these categories are commodity models transcending national boundaries and aggregating international supplies and demands for the given product. The need has been recognized for several years and a few working papers on the subject have been circulated at LINK meetings, but financial constraints have inhibited progress to date. The commodity models would be overlaid on the present LINK system to receive demand variables from the consuming countries and to feed back commodity prices for use in the import functions and domestic price equations of the country models. In this way the system could deal directly with such powerful sectoral inflationary pressures as the run-up of food prices owing to widespread crop failures in 1972-73 and the administered price increases for petroleum in 1973-74. Such sectoral price increases need not result in general inflation, of course, so the effects on the overall price level would depend also on the policy responses of the monetary and fiscal authorities.

If cartels continue to evolve for basic materials, the relevant commodity models must attempt to establish the limits for administered prices rather than provide point predictions for market clearing prices in a competitive framework. International political considerations will also be involved in price determination. Just as in the case of, say, domestic wage-push inflation, the international struggle for income-redistribution from the industrialized developed nations to the developing, raw material producing countries, has varying implications for the absolute price level as well as for relative prices, depending on policy responses around the world.

[23]McKinnon (1972) has also stressed the effects of productivity growth on the relative prices of internationally traded goods and other goods and services. Assuming that international commodity arbitrage keeps the (dollar) prices of tradables tied together fairly closely, he argued that the world (export) price level was essentially set by the U. S. price level as long as the world was on a dollar reserve standard. This view does not restrict the model to the "small country" case, since large economies other than the reserve currency country have internal overall inflation rates that depend on (1) the inflation rate of tradables in the reserve country, and (2) their own rates of productivity growth.



Finally, the reader will recall that exchange rates are exogenous in the present LINK system. The multiplier properties might be very different under a system of floating rates.[24] Freely floating rates could insulate the domestic money supply and price level from incipient surpluses or deficits in the balance of payments and facilitate the pursuit of independent fiscal and monetary policies. Destabilizing exchange speculation and cost-push domestic inflation induced by import price increases for a depreciating country are also possible, however. In any event, the stability properties of a flexible exchange regime cannot be investigated with the LINK system until capital flows and exchange rates are endogenized. In the likely event of floating but partially managed rates, the constituent national models would have to explain official reserve changes as well as exchange rates.

[24]For an interesting comparison of multipliers under alternative exchange regimes, see Rhomberg (1964).

# Appendix A

The purpose of this appendix is to examine the relationship between the implicit price deflators for GNP (PY) and final expenditure (PT) and to report price multipliers based on the latter indexes.

The formula for the deflator for final expenditure is repeated here for convenience:

$$PT = \frac{PY(Y) + PM(M)}{Y + M} \tag{A.1}$$

This expression may be re-arranged as follows:

$$PY = \frac{PT(Y + M) - PM(M)}{Y} \tag{A.2}$$

Total differentiation of (A.2) yields:

$$\begin{aligned} dPY = {} & dPT + (M/Y)\,(dPT - dPM) \\ & + (PT - PM)Y^{-2}\,(YdM - MdY) \end{aligned} \tag{A.3}$$

The last term measures the direct influence of changes in real income and imports on the relative changes in PY and PT. It is likely to be small since it is the product of two differenced terms and the quotient of squared GNP. (If the average and marginal propensities to import were equal on a *mutatus mutandus* basis — a condition that may be closely approximated in many models — YdM would equal MdY and the income term would be zero.) If the income term is ignored, $dPY = dPT$ whenever $dPT = dPM$. If $dPM > dPT$, then $dPY < dPT$, whereas the reverse is true if $dPM < dPT$. When the income term is not ignored, the condition for $dPY = dPT$ is more complicated, but it is still possible for dPY to be either smaller or larger than dPT.

A comparison of Tables A-1 — A-3 and 6 — 8 shows that the GNP deflator increases more than the final expenditure index in the simulations for Austria, Germany and Canada, so that the former actually overstates the increase in the latter. The direct cost impact of import price increases is doubtless to increase domestic prices by a lesser amount, but the indirect effects of higher import prices and larger export demands outweigh the direct impact. Further decomposition of the income and price impacts would require knowledge of the reduced forms relating PT, Y and M to the exogenous foreign variables, X (or PX(X)) and PM.

The simulations for Italy, the United States, and Japan reveal smaller price increases as measured by the GNP deflator, but the disparities are minor and the multipliers are weak on either measure.

Tables A-1 — A-3 contain a substantial number of negative entries, although they are less numerous and smaller than in Tables 6 — 8. Thus the earlier negative entries were partly the result of the deduction of import costs from the GNP deflator, but it is clear that domestic prices of final purchases also declined in most of the same instances.

## Appendix Table A-1

### International Elasticity Multipliers for Prices, First Year*

(Percentage price change of country in column induced per unit percentage income shock of country in row)

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | .08 | .00 | .00 | .02 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| Belgium | .00 | .07 | .00 | .01 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| France | .00 | -.01 | -.07 | .04 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| Germany | .02 | -.01 | .01 | .83 | -.02 | NA | NA | .01 | .01 | .00 | .00 |
| Italy | .00 | .00 | .00 | .03 | .07 | NA | NA | .00 | .00 | .00 | .00 |
| Sweden | .00 | .01 | .00 | .01 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| United Kingdom | .00 | -.01 | .00 | .02 | -.01 | NA | NA | .00 | .00 | .00 | .00 |
| United States | .00 | .00 | .01 | .04 | -.01 | NA | NA | .30 | .00 | -.02 | -.01 |
| Canada | .01 | .01 | -.09 | .02 | .00 | NA | NA | .02 | .01 | -.01 | .00 |
| Japan | .00 | .00 | .00 | .01 | .00 | NA | NA | .00 | .00 | .05 | -.01 |
| Australia | .00 | .00 | .00 | .01 | .00 | NA | NA | .00 | .00 | .00 | .07 |

(*) Price index is implicit deflator for final expenditure (equation 8).

NA — Not available.

# Appendix Table A-2

## International Elasticity Multipliers for Prices, Second Year*

(Percentage price change of country in column induced per unit percentage income shock of country in row )

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | .19 | .00 | .00 | .04 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| Belgium | .00 | .11 | .00 | .02 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| France | -.01 | -.02 | -.72 | .04 | -.02 | NA | NA | .00 | .01 | .00 | .00 |
| Germany | .04 | -.02 | .01 | 1.41 | -.03 | NA | NA | .01 | .03 | .00 | -.01 |
| Italy | .00 | .00 | -.01 | .04 | .03 | NA | NA | .00 | .01 | .00 | .00 |
| Sweden | .00 | .00 | .00 | .01 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| United Kingdom | .00 | .00 | .00 | .05 | -.01 | NA | NA | .01 | .02 | .00 | -.01 |
| United States | .00 | .00 | .01 | .09 | -.01 | NA | NA | .29 | .12 | -.01 | -.02 |
| Canada | .00 | .02 | .02 | .03 | .01 | NA | NA | .03 | .53 | .03 | -.01 |
| Japan | .00 | .00 | .00 | .02 | .00 | NA | NA | .00 | .01 | .04 | -.02 |
| Australia | .00 | .00 | .00 | .02 | .00 | NA | NA | .00 | .01 | .00 | .15 |

(*) Price index is implicit deflator for final expenditure (equation 8).

NA — Not available.



# Appendix Table A-3

## International Elasticity Multipliers for Prices, Third Year*

(Percentage price change of country in column induced per unit percentage income shock of country in row )

| | Austria | Belgium | France | Germany | Italy | Sweden | U.K. | U.S. | Canada | Japan | Australia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | .42 | .00 | .00 | .06 | .00 | NA | NA | .00 | .01 | .00 | .00 |
| Belgium | .00 | .10 | .00 | .02 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| France | -.01 | -.06 | -1.50 | .02 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| Germany | .13 | -.01 | .14 | 1.71 | -.07 | NA | NA | .04 | .09 | .00 | -.05 |
| Italy | .01 | .00 | -.01 | .07 | .30 | NA | NA | .01 | .02 | .01 | -.01 |
| Sweden | .00 | .00 | .00 | .02 | .00 | NA | NA | .00 | .00 | .00 | .00 |
| United Kingdom | .02 | .00 | .01 | .09 | .02 | NA | NA | .01 | .07 | .01 | -.02 |
| United States | .03 | .02 | .04 | .19 | .03 | NA | NA | .69 | .46 | .00 | -.05 |
| Canada | .01 | .03 | .02 | .06 | .02 | NA | NA | .05 | .94 | .01 | -.01 |
| Japan | .00 | .00 | .00 | .02 | .00 | NA | NA | .01 | .02 | .09 | -.03 |
| Australia | .00 | .00 | .00 | .01 | .00 | NA | NA | .00 | .02 | .00 | .16 |

(*) Price index is implicit deflator for final expenditures (equation 8).

NA — Not available.

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# Discussion

## R. J. Ball

The theory of the international transmission of fluctuations in income and prices has been examined extensively since the nineteen thirties. Inevitably perhaps the number of pages devoted to theory have far outweighed those given to reporting the results of measurement and attempts to put some quantitative skin onto the well-structured bones that our theories have provided. Sometimes we do not always agree about the theory and that heightens the need for more empirical work and testing of the nature of the relationships between countries.

That this is so, however, is not because of any inherent desire to theorize rather than to apply the results of theory but in large part because of the enormity of the task involved in what, in the end, amounts to modelling the economic world at large. We entertain reasonable doubt often about our capacity to reproduce the economic behaviour of small sectors of our economies let alone the economic environment as a whole while in addition the sheer magnitude of the research effort required to model individual economies in any detail before linking them together is extremely inhibiting. It is, therefore, little wonder that the empirical contributions made so far in trying to string the world together have been relatively simplified in structure.

In his paper today, Professor Hickman describes some results with regard to the transmission of changes in exogenous expenditures for several different country models engaged in the research project, Project LINK, and their impacts on incomes and prices in the domestic and the linked economies. The general outline of this project has been described in Ball (1973a) and is briefly summarized by Hickman in his paper. In general terms there is, therefore, little need for further discussion of the project, although one or two specific points are worth underlining as a background to the interpretation of Hickman's results.

The first is that the LINK system is in statistical terms like Jacob's coat of many colours. Some of the structural models contained in the Project are based on annual time series, and some are based on quarterly.

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Some of the models for different parts of the world are not structural at all, but are simply reduced-form expressions. Some of the models have been built relatively explicitly for forecasting purposes in the short term and are obviously used as such, while others are not used or tuned up to be operational on a day-to-day basis. This creates, of course, considerable managerial difficulties which in many respects in my view currently represent the most serious constraints on the speed of development within the Project.

The second point that is related to the first, is that inevitably the models themselves contain many special features and adjustments which operate satisfactorily within the framework of a given forecasting run but which are often less than satisfactory when we turn to the problems of simulation. As a single example one may refer to the fact that in the U.K. model there is no equation explaining the wage rate. Wage rates are forecast as exogenous variables, which may be quite reasonable within the framework of a specific forecast, but as Hickman's results show, produce a comparatively meaningless result with regard to price level effects when simulations are made. Thus, it is fair to say that currently the system as a whole is not tuned up as well as one would hope it will be in the longer run for simulation purposes. Professor Hickman's results must therefore be looked at in terms of a progress report about the kinds of numbers that currently tend to emerge from the machine, from a system that is under continuous development and which is by no means a finished product. The system continues to have weaknesses on other accounts, most of which are referred to in the Hickman paper. Even since the Project was described in Ball (1973b) the individual models have themselves undergone considerable development and there have been further changes even since the Hickman results were generated.

### *The Nature of the Multipliers*

Despite the heterogeneity of the models contained in the LINK system, the structural models for the major industrial countries have many elements in common which have been described at length in Ball (1973b). They are broadly speaking Keynesian-type expenditure models which suggest that, leaving the problem of lags on one side for the moment, the own-country multipliers are related to generalized Keynesian multipliers which include not only income-induced effects, but also effects resulting from changes in prices, monetary variables, and exchange rates, and feedback effects of the changes in these variables in other countries. In the context of balance-of-payments adjustment, multiplier analysis of the open economy has been examined by Stern (1973) while generalized multiplier analysis allowing for both price and monetary effects in a closed economy was presented in an earlier paper by Ball and Bodkin (1963). With some modification it may be useful to extend the results by Ball and Bodkin to the open economy in the case of the static multiplier, adopting in broad measure the assumptions that seem most common to the structural models of the LINK system.

The national income identity in the open economy can, as usual, be written in real terms as

$$Y = C + I + G + X - M \tag{1}$$

where Y = national income, C = consumption, I = investment, G = government expenditure, X = exports of goods and services, M = imports of goods and services. The LINK models do not by and large include monetary variables in the consumption function , so that consumption can in the main be assumed to be a function of income. So we have

$$C = C\,[(1 - t\,(PY))\,Y] \tag{2}$$

where P is the general price level and the function t(PY) reflects the existence of a progressive tax structure.

The bulk of the LINK investment functions are derived from versions of the capital stock adjustment principle, where the optimal stock of capital depends on output and cost of capital variables. For the purpose of short-term analysis, little harm is done by encapsulating the nature of behaviour in the familiar Keynesian investment function (i = rate of interest)

$$I = I\,(Y,i) \quad I_Y > 0 \quad I_i < 0 \tag{3}$$

In general one would expect the volume of imports to depend on both income and relative price, but this is not the case in all the LINK models. Generally speaking where they do exist, import price elasticities are relatively small — in total less than a half. To simplify matters here we express import volume solely as a function of income:

$$M = M(Y) \quad M_Y > 0 \tag{4}$$

Exports, on the other hand, are price sensitive in nearly all the LINK structural models, so we express the export function in the general form

$$X = X\,(P_x, P_w, W) \quad X_{px} < 0, X_{pw} > 0, X_w > 0 \tag{5}$$

where $P_x$ = export price, $P_w$ = world export price, W = volume of world trade.

The wage and price sector raises certain problems if the treatment of Ball and Bodkin (1963) is to be extended, which demand far greater discussion than can be given here. Consequently I simply follow the general description given by Hickman of the price and wage sectors in most of the LINK models. In particular for short-period purposes the wage price sector is represented by the set of equations

$$P_x = g\,(P, P_w) \tag{6}$$

$$w = w\,(P, Y) \tag{7}$$

where w = average money wage



$$P = P\,(w, Y, P_m) \tag{8}$$

where $P_m$ = import price.

The export price equation relates the export price to the domestic and world price levels. The wage equation is intended to capture the short-term Phillips curve effect through the income variable Y (which implicitly assumes that short-run changes in labor supply are negligible). Equation (8) represents a form of mark-up equation described by Hickman where the activity variable Y is assumed to be positively correlated with average productivity. For the purpose of simplifying the analysis I assume that equations (5) and (6) can be consolidated into

$$X = F\,(P, P_w, W) \quad F_p < 0 \quad F_{pw} > 0 \quad F_w > 0 \tag{9}$$

and (7) and (8) into

$$P = H(Y, P_m) \quad H_y > 0 \quad H_{pm} > 0 \tag{10}$$

This implies the weak assumption that the effect of a rise in the world price on own-country export price is not large enough to offset the positive effect of such a price rise on own-country exports. It implies the stronger assumption in (10) that the net effect of a rise in the level of activity will be to raise domestic prices.

Finally we introduce monetary effects through the familiar equation for monetary equilibrium so

$$L = L\,(PY, i) \tag{11}$$

where L = supply of money. Thus the complete model when finally assembled takes the form

$$Y = C + I + G + X - M$$

$$C = C\,[(1 - t\,(PY))\,Y]$$

$$I = I\,(Y, i)$$

$$X = F\,(P, P_w, W)$$

$$M = M\,(Y)$$

$$P = H\,(Y, P_m)$$

$$L = L\,(PY, i)$$

Given this system generalized multipliers can be devised as in Ball and Bodkin (1963), with the assumption that the system is well-behaved and stability exists. For present purposes it suffices to state and consider certain results. To simplify the multiplier expression we define

$$\alpha_1 = C_y [1 - t(PY) - t_y Y] - C_p t_p Y^2 H_y$$

$$\alpha_2 = I_y$$

$$m_1 = L_{ym} Y H_y + L_{ym} P$$

where $L_{ym} = \delta L / \delta(PY)$.

In this case the government expenditure multiplier in the closed economy can be written in the form

$$\frac{dY}{dG} = \frac{1}{(1 - \alpha_1 - \alpha_2) + m_1(I_i/L_i)} \qquad (12)$$

Thus we see that the multiplier can be partitioned into components, part of which is the traditional simple Keynesian income multiplier (allowing for taxation) and part of which represents the monetary effect on the system. In deriving this multiplier it is of course assumed that the quantity of money is held constant by the authorities. It follows that the greater the degree of sensitivity of investment to the interest rate the smaller the multiplier effect is likely to be. Thus strong monetary effects tend to damp down the multiplier and this would be true *a fortiori* if a real balance term were included in the consumption function.

In the open economy with no feed-back into external countries the government multiplier takes the form

$$\frac{dY}{dG} = \frac{1}{(1 - \alpha_1 - \alpha_2) + \beta_1 + m_1(I_i/L_i)} \qquad (13)$$

where $\beta_1 = M_y - F_p H_y$

The multiplier in the open economy is of course dampened not only by the leakage in imports, but also by the effect of the rise in domestic activity on export prices. Incorporating feed-back effects on the multiplier when external variables are allowed to vary is not so easy to handle. These effects can be formally if trivially introduced by defining the set of variables $k_i$ as

$$k_{pm} \equiv \frac{dP_m}{dY} \quad k_{pw} \equiv \frac{dP_w}{dY} \quad k_w \equiv \frac{dW}{dY} \qquad (14)$$



and expressing the multiplier in the form

$$\frac{dY}{dG} = \frac{1}{(1 - \alpha_1 - \alpha_2) + \beta_1 - f + [(I_i/L_i)(m_1 + m_2)]} \qquad (15)$$

where

$$f = F_p H_{pm} k_{pm} + F_{pw} k_{pw} + F_w k_w$$

$$m_2 = L_{ym} H_{pm} k_{pm}$$

The net effect of the feed-back on the sign of the multipliers is *a priori* unclear. The k variables could be expected to be non-negative. On this assumption, taking the terms one by one, one might suspect that the net effect would be to raise the multiplier but the question remains strictly open.

By and large, leaving the lags on one side, it is not unreasonable to treat the LINK system own-country multipliers of being of this general type. It is not always the case that monetary effects are well-treated by the individual countries, and some tendency to overestimate the multipliers may occur as a result of not building in appropriate assumptions about these effects. However, in many of the individual country cases these effects are by and large captured which represents, in principle at any rate, a considerable advance on the earlier work of Morishima and Murata (1972). In their case investment was treated as exogenous, there were no monetary effects, and the effects of taxation were excluded from the calculations. Under these circumstances it is extremely difficult to know what credibility can be assigned to their empirical results.

*Empirical Results*

Given what has already been said about the heterogeneity of the system it is also difficult to assess the multipliers given by Professor Hickman. It is difficult to test for reasonableness except perhaps to query some of the results that look palpably out of line with other countries and for which no special explanation can be found.

It would appear from the Hickman results that the feed-back effects on own-country multipliers are relatively small. That is to say the f term in equation (15) above is not of great significance. Taking the numbers given for comparison in footnote 17, there is a tendency for the multiplier on balance to be larger with linkage, but not significantly so. This seems to confirm the speculation above that linkage if anything would tend to raise the own-country multiplier. However, it might be worth considering how this conclusion holds over time rather than simply for the one-year multiplier, since the feed-back effects could probably become greater in the longer term.

With regard to the cross-country elasticity multipliers, the assumption would be that countries with obviously closer trading relationships with certain others should have larger mutual effects. The patterns of linkage are not very clear except for the outstanding effect of the U. S. economy on Canadian income. In principal the LINK system should capture the linkages through activity, as in effect the activity variable determining each country's exports is an appropriately weighted average of the import demands of the different component countries.

In response to the specific conclusion drawn by Professor Hickman on the basis of the income calculations, I make only two points. One is that I do not really follow the argument that says that the United States materially affects overseas countries because of its large size. How does one then explain the kind of impact made in these calculations by Germany? Equally, it could be argued that the Australian external effects look relatively large insofar as Australia is of course relatively small. Secondly while it was not possible for Professor Hickman to do otherwise, experience in some cases suggests that a much longer period than three years is required to get to some kind of equilibrium picture. On some future occasion an extension of the period of simulation would be helpful.

Unfortunately, at the present time one must have some doubts as to whether the LINK system adequately captures the essential inter-connections between prices. While there have been attempts in the past to model the interrelationships of income, little work has been done on prices and perhaps the LINK system as it is at present is as good as there is. But as of now, the limitations of the modelling of the monetary flows combined as Professor Hickman points out with a lack of well-developed models for the world's major commodities make it difficult to replicate adequately the recent sharp movements in world prices.

What currently emerges from the LINK system simulation of own-country prices multipliers are indeed positive price effects from shocks to government expenditure (with the exception of the odd cases of France, the Middle East and the United Kingdom). The remaining results are so diverse that it is difficult to say anything very significant. But they tend to confirm the general assumption imposed earlier on the simple model of the economy that $H_y > 0$.

The results as expressed by the cross-multipliers deepen rather than enlighten with regard to the mystery as to international price linkage. Any suggestion that world inflation might result from a concomitant and independent set of exogenous shocks on cost levels within countries does not square with many people's intuition. Hickman concludes that the results suggest that world inflation cannot be attributed to the spread of demand impulses from one or two countries via foreign trade in merchandise. They are certainly consistent with that view but with the admitted non-existence of adequate modelling of both monetary effects and commodity markets it can hardly be a definitive conclusion. Moreover it is likely that the actual course of world prices has been a more complex interaction of



world demand pressures, monetary policies and cost inflation elements than can at present be replicated by LINK systems.

There is, however, a further price simulation which might be of interest. A curious theory has been propounded in the United Kingdom by Neild and others that suggests that a country's balance-of-payments difficulties cannot be attributed to exogenous shifts in the import price level. The crude version of the argument suggests that the deflationary effect of rising import prices will offset the price effect on the current account of the balance of payments. What began as a parochial argument in the context of the U.K. economy is however of wider significance when we come to consider the impact of the rise in the price of oil and its deflationary effects on the economics of the non-oil producing world.

Using the simple model set out earlier it can be shown that the own-country multiplier with respect to import prices (and a second party feed-back) can be expressed in the form

$$\frac{dy}{dP_m} = \frac{H_{pm}(F_p + C_p t_p Y^2) - (I_i/L_i)(L_{ym} Y)}{(1 - \alpha_1 - \alpha_2) + \beta_1 + m_i(I_i/L_i)} < 0 \qquad (16)$$

Thus import prices squeeze real income through the effect on export prices, the effect on consumption through fiscal policy and the effect on investment from higher interest rates. It is not easy to apply any immediate orders of magnitude to the individual elements of (16). However, some further insight may be obtained by differentiating the balance-of-payments current account identity

$$B = P_x X - P_m M \qquad (17)$$

which gives us

$$\frac{dB}{dP_m} = \frac{dP_x}{dP_m} X(1 + E_x) - M(1 + E_{pm} E_{my}) \qquad (18)$$

where $E_x$ is the total elasticity of exports with regard to export price. $E_{pm}$ represents the total elasticity of imports with respect to import price, and $E_{my}$ the income elasticity of imports. Clearly the import price simulations for an individual country are crucial to determining the long-term effect of the external price rise, in particular to the extent to which the natural deflationary forces set up by the price increase will offset the impact effect of the price rise on the current account of the balance of payments. There is certainly no *a priori* presumption that the permanent effect on the balance of payments will not be substantial. Strictly speaking, the extent to which this is so would have to be established country by country by simulation. However, in terms of (18), preliminary simulations of the U.K. economy suggest that the total import price elasticity is likely to be of the order of -0.25. If this were a fairly general result across countries, and given that the income elasticity for most countries is likely to be of the order of 1 — 1.5 it seems *a priori* unlikely that less than half of the impact effect of an exogenous change in import prices on the balance of payments will be avoided.

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