Modeling the Effects of Foreign Prices on Domestic Price Determination:

Some Econometric Evidence and Implications for Theoretical Analysis

Events of the last decade have stimulated considerable interest, on the part of international economists, in the subject of the international transmission of inflation. After many years in which international macroeconomics was dominated by the extreme Keynesian assumption that prices were fixed,[1] models have begun to appear with increasing frequency in which prices are somehow allowed to move. The bulk of these flexible-price models, however, have taken an extreme position opposite to that of Keynes by assuming that prices adjust freely to maintain full employment.[2] While such models contribute much to our understanding of macroeconomic equilibria, they do little to elucidate the disequilibrium and dynamic behaviour that is so important in the short run. In particular, by letting prices be determined entirely by the requirements of macroeconomic equilibrium, they bypass the issues of how prices and wages are set in the short run and whether there is any direct linkage between domestic price and wage formation and the levels of prices and wages internationally.[3] Such direct linkages between international and domestic prices and wages are the subject of this paper.

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[1] Classic examples of fixed-price models are those of METZLER (1942) and MACHLUP (1943), neither of whom included monetary sectors, and TSIANG (1961) and MUNDELL (1963), who did.

[2] MUNDELL, again, in several chapters of his book (1968) made this assumption, as have most of the papers which develop the monetary approach — see FRENKEL and JOHNSON (1976). The fixed price and full employment versions of both Keynesian and monetary models are contrasted in DEARDORFF (1977).

[3] We should acknowledge that attempts have been made to make both the price level and output variable in an international context. STERN (1973, pp. 224 and 348-51) contains two appendices by J. D. Richardson, in which the domestic price level is taken as an increasing function of domestic output in the context of an open economy model. This function can be thought of as representing the aggregate supply curve as derived for a closed economy by, for example, BRANSON (1972, Ch. 7).

Direct price linkages have been included in only a few, recently-developed, theoretical macroeconomic models. Turnovsky and Kaspura (1974), and subsequently Caprio (1976), incorporated a Phillips Curve into their models and explicitly allowed the domestic rate of inflation to depend in part on the rate of increase in import prices. In the one-period analysis that they employed, taking all lagged prices as given, this is equivalent to letting the domestic price level depend directly on the level of import prices. In another development, the Scandinavian approach to international macroeconomics has stressed the importance of international prices for domestic wage determination in a small open economy.[4] This approach has been formalized and integrated with the Keynesian and monetary approaches by Calmfors (1976). Aside from these few papers, there appears to have been very little effort made to account for international influences on domestic price formation at the theoretical macroeconomic level. The evidence we present below suggests that this may be an omission of considerable importance.

We begin with a brief theoretical discussion of international price relationships. This discussion is intended more to provide background for our subsequent empirical analysis than to be exhaustive. We then devote the remainder of the paper to an analysis of empirical evidence as contained in several large econometric models. This evidence is taken from a more comprehensive study of international economic interdependence — see Deardorff and Stern (1977) — in which we had occasion to analyze several large national econometric models and some linked intercountry models. We do not, then, present any new evidence of our own, nor do we attempt to survey the entire literature on the subject.[5] Our purpose is rather to bring together in one place a body of evidence that is otherwise likely to be neglected by international economists, imbedded as it is within large and complicated econometric models, many of which may appear to be relevant only for particular nations or groups of nations.

It is our view that econometric models, even of individual countries, can only be successful as tools for forecasting or domestic policy

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Indeed, this interpretation was made explicit when the same approach was used to study the transmission of inflation by BRANSON (1975). In neither case, however, were foreign prices allowed to enter the supply function.

[4] See EDGREN, FAXÉN and ODHNER (1974) and AUKRUST (1975).

[5] Other empirical work on this subject seems, in any case, to be limited. The best and most recent is CALMFORS and HERIN (1977), which also gives reference to earlier work.

analysis if they accurately model international linkages with the rest of the world. Therefore, the better of these models should have something of interest to say for international economics generally, on both empirical and theoretical grounds. We feel that the evidence to be presented in this paper bears out this contention.

I. Theoretical Considerations

Our concern here is why domestic prices may depend on foreign prices. Such a relationship may either be static, relating the levels of the two prices, or dynamic, relating their rates of change over time. We have been able to identify five reasons for such a relationship for which the mechanism of cause and effect is sufficiently direct to be observable in the separate equations of an econometric model. In addition, we mention a sixth reason that emerges from general equilibrium considerations and which cannot therefore be observed directly.

The first reason is the most obvious, but it is also the least interesting, since it has little to do with price formation. It is clear that any general price index for a country must incorporate the prices of all goods for which it is an index. If these goods are partly imported, then import prices will enter the definition of the domestic index. For example, if consumption includes imports, then the consumer-price index will vary with import prices, with an elasticity that roughly equals the share of imports in consumption. Unfortunately, this relationship, which as we shall see is the easiest to measure, is not really relevant since such price indices do not represent prices of domestic products alone. Ideally, we would like to find effects of foreign prices on the prices actually charged for domestically produced goods. The remaining reasons do deal with such effects.

The second reason arises from the natural extension of the aggregate supply curve to an open economy in which intermediate inputs are traded. In its neoclassical form, the aggregate supply curve reflects marginal cost pricing. The price of output is its marginal cost, and thus rises with output due to diminishing returns to labor, given a fixed capital stock and a fixed money wage. In an open economy if some variable inputs are imported, then an increase in their price also raises marginal cost and shifts the aggregate supply curve upward.

The third reason is similar to the second but arises in a nonneoclassical world of "mark up" pricing. Again if inputs are imported, an increase in import prices raises average cost and, given a fixed mark up, also raises the price charged for output. This is the rationale adopted in the slightly more dynamic context of the Phillips Curve by Turnovsky and Kaspura (1974).

The fourth reason also requires some departure from the assumptions of perfect competition. As foreign prices rise, those domestic producers of import substitutes will find it profitable to raise their own profit margins. Thus, without any change in costs, we may find the prices of domestic products responding to foreign prices.

The fifth reason works through wages. There is mounting evidence that money-wage changes are responsive to either actual or expected price changes, as workers focus on *real* wages in their negotiations and bargaining with employers. Since the real value to a worker of a particular money wage depends in part on the price of the imported goods he plans to consume, it follows that import prices will have a positive effect on wages. To the extent that wages in turn affect prices, we get again a positive effect of foreign prices on domestic prices.

Finally, there is a sixth reason for international price interdependence that does not involve any direct linkage of prices or wages, but instead arises from the influences of aggregate demand. When foreign prices rise, demand both at home and abroad will substitute toward domestically-produced goods. Depending on which foreign prices are affected, this increase in demand may be felt primarily in the export sector or in the import-competing sector. But in either case the result is an increase in aggregate demand for domestic goods. This in turn will cause a bidding up of both domestic prices and outputs, even if there is no direct linkage of foreign prices with domestic price or wage formation. This sixth reason for price interdependence is too indirect in its operation for it to be observed in the separate equations of large econometric models, and we will therefore not consider it further in this section. It may nonetheless account for a significant part of the price interdependence that has been observed in the simulation of linked models which we examine below in Section III.

The first five effects are summarized in Table 1. For each effect, the chain of causation that we have already described is represented for ease of comparison. We will now investigate which, if any, of these effects have been incorporated into the various econometric

models that have been examined. Note that while the chains of causation differ considerably among the five effects, all share the same end result: that certain foreign prices act *positively* on certain domestic prices.

II. Evidence from Selected National Econometric Models

As already mentioned, in Deardorff and Stern (1977), we have undertaken a comprehensive analysis of the various kinds of international economic interdependence, of which foreign price transmission is one, and have examined several large-scale national econometric models for their empirical representation of transmission phenomena. For this purpose, we used the 1974-75 versions, which were the latest available at the time of writing, of the RDX2 and TRACE models of Canada, the London Business School (LBS) and U.K. Treasury (UKT) models of the United Kingdom, and the Kyoto University (KYQ75)

TABLE 1

THEORETICAL MECHANISMS FOR DEPENDENCE OF DOMESTIC PRICES ON FOREIGN PRICES *

1. *Price Index Effect*
   Prices of imported final goods.
   → Domestic price index for an expenditure category that includes imports
2. *Marginal Cost Pricing Effect*
   Prices of imported intermediate inputs
   → Marginal cost of output
   → Price of output
3. *Mark-up Pricing Effect*
   Prices of imported intermediate inputs
   → Average cost of output
   → Price of output
4. *Foreign Competition Effect*
   Prices of imports or of foreign goods
   → Demand for import substitutes or exports
   → Profit margin of imperfectly competitive domestic producers
   → Price of import substitutes or exports
5. *Wage Effect*
   Prices of imported consumption goods
   → Domestic consumer price index (or its expected rate of change)
   → (negatively) Actual or expected real wage
   → Negotiated money wage
   → Cost of output (marginal or average)
   → Price of output

* Arrow denotes causation which is positive unless otherwise indicated.

model of Japan.[6] We did not consider any U.S. models in part because they were so numerous, but more because most of the extant models do not include foreign transmission effects in a systematic manner.

Our examination of the aforementioned models consisted, first, of an analysis of the individual equations containing domestic and foreign price relationships. We then considered any available model simulations. The only one that was relevant in the present context was a simulation of RDX2 of the effects of foreign price inflation on the Canadian economy.

Evidence from Model Equations

Our analysis of the price equations in the five national models disclosed that most of the domestic price variables involved were in fact indices for categories of expenditure rather than for goods produced domestically. As is evident in Table 2, these price variables quite often depend on foreign or import prices. Since many of the equations included lagged variables, we attempted to show both the impact and steady-state effects (indicated by an arrow) in the next-to-last column of the table. When the results were not altogether clear, we made a guess (in parentheses) as to the sign and dynamic behavior. The last column records the t-ratio in so far as it could be determined.

Since the price measures used in the equations were presumably index numbers expressed with a common base, it would be reasonable to interpret the coefficients listed as elasticities. Given that the expenditure categories noted typically included some imports, the dependence of their corresponding price indices on foreign prices could well be totally accounted for by the first of the five effects listed in Table 1. On the other hand, it is impossible to know for sure that such dependence is *only* the result of the first effect. It would be instructive to compare the reported estimates with the corresponding shares of imports in expenditure, since an estimate in excess of the import share would be evidence that some effect other than the first must be present. Unfortunately, information on appropriate import shares was not readily available to us. It appears, however, that several of the coefficients in Table 2 are sufficiently high, especially in the long run, that they cannot be accounted for solely by index-number considerations and therefore reflect a definite impact of foreign prices on domestic price determination.

[6] Details on the general characteristics and on the foreign-sector equations of these models are contained in Deardorff and Stern (1977, App. A and B).

Table 2

DOMESTIC EXPENDITURE PRICES AS DEPENDENT ON FOREIGN AND IMPORT PRICES

Model	Dependent Variable: Price or Deflator for	Independent Variable: Price of	Coefficient	Significance: t-Statistic
(1) RDX2	Consumption of Motor Vehicles	U.S. Consumer Durables	.009 → .551	approx. 3.0
(2)	Investment in Machinery & Equip.	U.S. Producer Durables	.137 → .473	approx. 3.0
(3)	Consumption of Nondurables & Semidurables	Various Imports	.123 → .023	approx. 3.0
(4) TRACE	Consumption of Nondurables & Services	Imports	.21	1.97
(5)	Investment in Machinery & Equip.	Imports of Goods	.49 → 1.5	2.81
(6) LBS	Consumption Expend.	Imports of Goods and Services	.221	10.9
(7)	Gross Domestic Fixed Capital Form.	Imports of Goods and Services	.214	n.a.
(8)	Public Sector Expenditure on Goods and Services	Imports of Goods and Services	.154	n.a.
(9)	Public Sector Capital Formation	Imports of Goods and Services	.240	3.55
(10) UKT	Consumption Expend.[a]	Various Imports	(+ → 0)	n.a.
(11)	Gross Fixed Capital Formation	Imports of Nonfood Products	0.0 → .28	coeff. imposed
(12)	Inventories	Imports of Nonfood Products	.03 → .291	n.a.
		Imports of Food, etc.	.109 → .181	n.a.
(13) KYQ75	Metal & Metal Products (Wholesale)	Imports of Metal & Metal Products	.82	21.7
(14)	Miscellaneous Products (Wholesale)	Imports of Miscellaneous Products	.47	16.6
(15)	Chemicals (Wholesale)	Imports of Chemicals	.46	19.0

[a] Equation expressed in first differences.

In search of evidence for the other effects from Table 1, we also tried to identify price variables in the models that either were more associated with output than with expenditure, or that depended on particular foreign prices that would not directly enter the index of domestic prices. Instances were found in four of the five models, and these are reported in Table 3.

The TRACE model contained a variable as the "deflator for output in business non-agriculture." This is constructed from real and nominal GNP. Since imports are netted out of both of these, it appears that the output-price deflator reflects prices only of goods that are produced at home. Its dependence on prices of imports therefore gives evidence of one of the effects 2, 3 or 4 in Table 1, though it is impossible to say which.

The LBS model included an equation for the price deflator for exports of goods and services that contained as independent variables measures of the prices of imports of goods and services and of world exports of manufactures. The first of these again incorporates effects 2, 3 or 4 in Table 1, while the second seems to represent effect 4 with regard to foreign competition.

The UKT model included an index of the *costs* of manufactured exports that depended positively on import prices. This is the clearest example of cost effects — types 2 or 3 —that we were able to find. Unfortunately, the coefficients indicated were imposed rather than estimated.

The remaining cases of what appeared to be product-price effects were found in the Japanese model, KYQ75. In that model, two wholesale price indices appeared, one for manufactures only and one overall, and were positively dependent on prices of exports and on prices of imports of materials. The dependence on export prices seems to be a clear example of our fourth effect in Table 1 — the effect of competitive prices. At the same time, dependence on prices of materials imports seems again to reflect their role in costs.

Finally, we looked at the wage equations of the models to see whether the fifth effect in Table 1 could be found. We found it to be clearly present in three of the models, but we did not tabulate the results, since no quantitative information was available. We merely report that the wage equations in all of these models depended positively on consumer prices, either directly in a real wage term, or

TABLE 3

DOMESTIC PRODUCT PRICES AS DEPENDENT ON EXPORT AND IMPORT PRICES

Model	Dependent Variable: Price or Deflator for	Independent Variable: Price of	Coefficient	Significance: t-Statistic
(1) RDX2	None			
(2) TRACE	Output in Business and Nonagriculture	Imports of Goods	.15 → .18	1.79
(3) LBS	Exports of Goods and Services	Imports of Goods and Services	.13	n.a.
		World Exports of Manufactures	.37	9.16
(4) UKT	Manufacturing Exports (Cost)	Imports, exc. Food, Drink & Tobacco	.05 → .20	coeff. imposed
(5) KYQ75	Wholesale Prices (Overall)	Exports	.35	7.50
		Imports of Materials	.34	17.8
(6)	Manufactures (Wholesale)	Exports	.35	7.11
		Imports of Materials	.33	16.2

indirectly through an endogenous expectations term. Since consumer prices in turn always depended on import prices, this yielded the expected positive effect.

The evidence summarized in Tables 2 and 3 clearly shows that foreign prices are an important determinant of domestic prices via the prices of imports. Such an effect was found in all of the models that we examined, although the nature of the theoretical relationship was often obscured because of the use of expenditure deflators as dependent variables. Where available, the elasticities suggested were significant both statistically and in their size. The dynamic behavior of the 20 equations examined indicated 11 with coefficients that stayed constant from impact to steady state, 8 with coefficients that increased, and 1 with coefficients that went to zero.

Evidence from Simulation of RDX2

Of the five models considered, RDX2 is by far the most sophisticated and complete, especially in terms of its treatment of monetary influences, international capital movements, and both fixed and flexible exchange-rate regimes. Aubry and Kierzkowski (1976) have simulated, using RDX2, the effects on the Canadian economy of a "pure" foreign price shock, in which foreign prices were assumed to have increased by 1 per cent per annum more than they actually did for the period, 1963I to 1976IV.

As noted earlier, foreign prices enter into the determination of the various expenditure deflators in the RDX2 model. Other variables determining the deflators include unit labor cost, capital cost, and a capacity index. In the context of their simulation, Aubry and Kierzkowski have calculated the elasticities of the Canadian consumer-price index and its components with respect to the main explanatory variables just mentioned. These elasticities were apparently calculated directly from the price equations of the model, rather than from the results of the simulation, and thus represent only partial effects. They are summarized in Table 4. It is evident that a 1 per cent increase in foreign prices eventually generates a 0.2 per cent increase in the consumer price index for Canada, this effect being direct and independent of any further influence through labor costs or capacity. This direct effect can be seen to operate primarily through the prices of consumer nondurables and semidurables and of consumer motor vehicles, where the foreign price elasticities are considerably

larger. The small but positive effect on the deflator for gross rent comes from the higher prices of materials for residential construction.

While these direct effects of foreign prices are large enough to be important, it is also clear from Table 4 that the major determinant of Canadian consumer prices is unit labor cost. This could actually add to the importance of foreign prices, however, to the extent that wages are themselves dependent on foreign prices. Such dependence has already been discussed above as the fifth of our reasons for price interdependence, and could also arise through general equilibrium interactions of aggregate demand and the Phillips Curve. Aubry and Kierzkowski do not provide direct evidence of such effects, but it can nonetheless be inferred from a comparison of their simulation results with the elasticities reported in Table 4.

The simulation results are given in Table 5 for the fixed and flexible exchange-rate cases. In the fixed exchange-rate case, where foreign price changes translate directly into import-price changes, it is clear that all Canadian consumer prices rose substantially more than could be accounted for by the direct foreign price elasticities alone. Over 10 years of the simulation, in which foreign prices increased by slightly more than 10 per cent, the consumer price index rose by 6 per cent. Only one third of this increase can be accounted for by the direct price elasticity reported in Table 4. That something other than the direct effect was operating is most obvious in the cases of deflators

TABLE 4

RDX2: ESTIMATED ELASTICITIES
OF THE CONSUMER PRICE INDEX AND ITS COMPONENTS

	Domestic Price Elasticities with Respect To:					
	Foreign Prices		Unit Labor Cost		Capacity	
	Impact	Long Run	Impact	Long Run	Impact	Long Run
Consumer price index	.060	.195	.125	.713	.093	.296
Price deflator for consumer nondurables and semidurables	.109	.290	.097	.569	.133	.354
Price deflator for consumer motor vehicles	.040	.284	.385	1.228		
Price deflator for other consumer durables			.201	.287		
Price deflator for consumer services, excl. rent and property taxes			.107	.993	.100	.395
Price deflator for gross rent	.0003	.112	.001	.387	.001	.101

Source: Aubry and Kierzkowski (1976, p. 27).

TABLE 5

RDX2: ANALYSIS OF THE RESPONSE OF THE CONSUMER PRICE INDEX AND COMPONENT INDEXES TO A FOREIGN PRICE SHOCK UNDER A FIXED AND FLEXIBLE EXCHANGE-RATE REGIME

(Percentage differences from control)

Quarter	Deflator for Consumer Non-durables and Semi-durables		Deflator for Consumer Motor Vehicles		Deflator for Other Consumer Durables		Deflator for Consumer Services		Deflator for Gross Rent		Consumer Price Index	
	Fixed	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed	Flexible
4Q63	.19	.19	.10	.10	.00	.10	.00	.09	.00	.00	.14	.14
4Q64	.57	1.05	.61	.51	.10	.30	.09	.36	.10	− .20	.43	.67
4Q65	1.02	2.23	1.23	1.30	.29	.88	.34	1.21	.39	− .10	.80	1.60
4Q66	1.52	2.41	2.04	2.75	.38	1.05	.66	1.81	.87	.30	1.24	2.04
4Q67	2.27	1.57	2.84	3.53	.64	.55	1.09	1.63	1.31	.74	1.92	1.64
4Q68	3.01	.08	4.01	3.06	.90	− .45	1.76	.66	1.80	.90	2.68	.55
4Q69	3.83	−1.30	5.41	1.31	1.15	−1.15	2.57	− .55	2.37	.76	3.48	− .67
4Q70	4.94	−1.94	7.02	−1.08	1.40	−1.23	3.23	−1.31	3.27	.15	4.53	−1.50
4Q71	5.32	−2.27	8.74	−2.77	1.59	− .97	3.95	−1.63	4.24	− .62	5.21	−1.97
4Q72	5.99	−1.12	9.94	−3.22	1.67	.09	4.49	−1.18	5.19	−1.32	5.92	−1.33
4Q73	6.24	.40	11.70	−2.54	1.71	.85	4.88	− .05	6.08	−1.47	6.42	− .16

Source: Aubry and Kierzkowski (1976, p. 29).

for other consumer durables and consumer services. These rose substantially even though their direct foreign price elasticities were zero. Finally, we can infer that the bulk of this indirect effect occurred through wages, since the increases in prices were strongly correlated with the unit-labour-cost elasticities reported in Table 4.

Some indication of the time patterns of response of the various deflators is also given in Table 5 for the fixed and flexible exchange-rate cases. For fixed rates, the response was fairly slow for the first four years. This was followed by acceleration and then some slowing down in the final period. The most noteworthy result of the flexible exchange-rate regime is that the exchange-rate movement at a certain level tends to isolate Canadian prices from foreign inflation. Thus, compared to the fixed rate regime, when adjustment occurs slowly through an increase in domestic prices, the adjustment to foreign inflation under flexible rates comes mainly and more rapidly in the form of an appreciation of the Canadian dollar. This difference in the speed and level of adjustment under both exchange-rate regimes can be seen in Table 6.

In the last column of Table 6, we have calculated the difference between the foreign price changes in column (1) and the exchange-rate changes in column (4). Since the latter reflect the price of the Canadian

dollar (rather than its reciprocal) this difference corresponds to the change in the Canadian dollar price of imports. The importance of this price for Canadian consumer price is indicated by the similarity of columns (3) and (5) for most of the 10-year period.

TABLE 6

RDX2: CONSUMER PRICE AND EXCHANGE-RATE ADJUSTMENT TO A FOREIGN PRICE SHOCK UNDER A FIXED AND FLEXIBLE EXCHANGE-RATE REGIME

(Percentage differences from control)

Quarter	Foreign Price	Consumer Price Index	Consumer Price Index	Exchange Rate	(1) – (4)
		(Fixed ex. rate)	(Flexible exchange rate)		
	(1)	(2)	(3)	(4)	(5)
4Q63	1.00	.14	.14	– .02	1.02
4Q64	2.02	.43	.67	–1.15	3.17
4Q65	3.04	.80	1.60	1.54	1.50
4Q66	4.08	1.24	2.04	.87	3.21
4Q67	5.12	1.92	1.64	3.64	1.48
4Q68	6.18	2.68	.55	5.65	.53
4Q69	7.24	3.48	– .67	7.39	– .15
4Q70	8.32	4.53	–1.50	9.24	– .92
4Q71	9.40	5.21	–1.97	9.19	.21
4Q72	10.50	5.92	–1.33	7.74	2.76
4Q73	11.61	6.42	.16	6.94	4.67

Source: Aubry and Kierzkowski (1976, p. 35).

III. Evidence from Linked Models

In addition to the national econometric models, we also had occasion to examine simulations of models that contained explicit international linkages for two or more countries. These latter models included: Project LINK, the mini-METEOR model developed by the Netherlands Central Planning Bureau, and the COMET model of the European Community.[7]

7 See DEARDORFF and STERN (1977, App. A and B) for a description of these models. We used the 1974-75 versions, which were the latest available at the time of writing. In addition to the COMET model, we also examined the DESMOS linked model of the European Community. But since no exogenous price changes were simulated in the version of the DESMOS model that was available, we did not consider it further for the purpose of this paper.

Project LINK

The LINK model has been used by Johnson and Klein (1974) to analyze the impact of higher world raw materials prices (including oil) and the impact of synchronized wage rate shocks under conditions of fixed exchange rates.

The simulated effects of higher world raw materials prices are indicated in Table 7, in the form of the percentage change in the shocked as compared to the control solution for 1974 and 1975. The impact on import prices, indicated in column (1), was positive for all of the countries listed. The domestic price increases are shown for the GNP deflator, consumer-price index, and export-price index in columns (2)-(4). We have also calculated the ratio of the percentage changes in the domestic prices with respect to import prices, in columns (5)-(7). The impact on the GNP deflator was positive for all countries, except for Australia and Italy, and equal to zero for the U.S. The impact on the consumer-price index was similarly positive throughout, except for Australia and Italy, and export prices increased in all instances. The large percentage increase in the export prices of the developing nations is indicative of the exogenous increase in foreign prices.

Columns (5)-(7) of Table 7 provide some guide to the elasticities of domestic prices with respect to import prices. These are not elasticities in the usual *ceteris paribus* sense, since they reflect the full solution of each country's model, including the linkages. If we disregard the apparently anomalous results for Australia and Italy, the elasticities of the GNP deflator with respect to import prices range from zero for the U.S. to greater than 2 for the Netherlands. The elasticities of the consumer-price index range from slightly positive for the U.S. to about 1.9 for Canada. The elasticities for export prices range from slightly positive for Sweden to more than 2 for the Netherlands.

The simulation results of synchronized wage shocks in the industrialized countries are unfortunately difficult to interpret and are therefore not reported here. The problem is that the increased wages feed into higher domestic prices in all the countries, and, there are subsequent changes in foreign trade prices that are transmitted among countries. All countries in the simulation — see Johnson and Klein (1974, pp. 181-82) — experienced higher import prices in comparison to the control solution, which presumably had a further impact on domestic prices. But the information given did not distinguish the separate effects of the increases in wages and in import prices.

TABLE 7

PROJECT LINK SIMULATION OF THE EFFECTS OF PRICE INCREASE OF DEVELOPING NATIONS' EXPORTS, 1974-75

(Percentage Change of Control Solution)

Country	Year	%ΔPM (1)	%ΔPGNP (2)	%ΔPC (3)	%ΔPX (4)	(2) ÷ (1) (5)	(3) ÷ (1) (6)	(4) ÷ (1) (7)
Australia	1974	+4.5	−1.1	−0.3	0.0	−0.24	−0.47	0.0
	1975	+5.1	−2.0	−0.8	0.0	−0.39	−0.16	0.0
Austria	1974	+1.9	+0.4	na	+0.2	+0.21	na	+0.11
	1975	+2.1	+0.3	na	+0.2	+0.14	na	+0.10
Belgium	1974	+4.4	+0.9	na	+4.9	+0.20	na	+1.11
	1975	+4.4	+1.4	na	+5.2	+0.32	na	+1.18
Canada	1974	+1.3	+1.3	+1.6	+0.9	+1.00	+1.23	+0.69
	1975	+1.5	+2.7	+2.8	+0.9	+1.80	+1.87	+0.60
Finland	1974	+2.8	+0.2	na	+0.2	+0.07	na	+0.07
	1975	+3.6	+1.2	na	+0.2	+0.33	na	+0.06
France	1974	+5.8	+2.6	+3.3	+3.8	+0.45	+0.57	+0.66
	1975	+6.0	+3.7	+3.5	+3.8	+0.62	+0.58	+0.63
Germany	1974	+6.0	+0.3	na	+0.1	+0.05	na	+0.02
	1975	+6.2	+0.7	na	+0.2	+0.11	na	+0.03
Italy	1974	+9.0	0.0	−0.2	+5.7	0.0	−0.2	+0.63
	1975	+9.1	−0.3	−0.3	+6.8	−0.03	−0.3	+0.75
Japan	1974	+9.5	+0.1	+1.0	+2.2	+0.01	+0.11	+0.23
	1975	+9.6	+2.0	+1.9	+4.1	+0.21	+0.20	+0.43
Netherlands	1974	+2.0	+4.6	na	+4.2	+2.30	na	+2.10
	1975	+2.3	+4.9	na	+2.5	+2.13	na	+1.09
Sweden	1974	+5.0	na	+0.5	+0.2	na	+0.10	+0.04
	1975	+5.4	na	+0.9	+0.2	na	+0.17	+0.04
United Kingdom	1974	+7.7	[a]	+1.5	+2.5	na	+0.19	+0.32
	1975	+7.9	[a]	+1.6	+2.7	na	+0.20	+0.34
United States	1974	+4.8	0.0	+0.2	+0.8	0.0	+0.04	+0.17
	1975	+5.7	0.0	+0.3	+0.9	0.0	+0.05	+0.16
Dev. Nations	1974	+5.2	+0.8	na	+26.0	+0.15	na	+5.00
	1975	+5.8	+1.2	na	+28.2	+0.21	na	+4.86
Rest of World	1974	+3.4	na	na	+2.9	na	na	+0.85
	1975	+4.1	na	na	+4.9	na	na	+1.20

[a] U. K. output assumed to be supply constrained under these circumstances.
na = not available
PM = import-price index; PGNP = implicit deflator of GNP (GDP)
PC = consumer-price index; PX = export-price index

Source: Adapted from Johnson and Klein (1974, pp. 173-74).

Mini-METEOR

Simulations of the mini-METEOR model have been made for sustained autonomous increases of 1 per cent in domestic prices and, alternatively, in wage rates under fixed exchange rates. The domestic price simulations are summarized in Tables 8-10 for years 1 and 2 and for the 5-year total. The effects on import prices, shown in Table 8,

TABLE 8

MINI-METEOR SIMULATION OF EFFECTS OF DOMESTIC PRICE CHANGES ON IMPORT PRICES

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

		United States	Belgium	France	Germany	United Kingdom
Canada	1ST YR	.121	.004	.009	.017	.015
	2ND YR	.179	.009	.021	.039	.037
	5YRTOT	.242	.020	.037	.079	.065
United States	1ST YR	.041	.006	.012	.027	.017
	2ND YR	.093	.012	.026	.054	.044
	5YRTOT	.120	.021	.032	.086	.058
Japan	1ST YR	.084	.004	.011	.020	.012
	2ND YR	.157	.009	.025	.047	.043
	5YRTOT	.144	.014	.014	.055	.034
Belgium	1ST YR	.034	.004	.039	.055	.019
	2ND YR	.073	.011	.063	.090	.042
	5YRTOT	.127	.025	.098	.156	.072
France	1ST YR	.047	.019	.009	.049	.015
	2ND YR	.097	.029	.023	.083	.041
	5YRTOT	.129	.050	.033	.135	.057
Germany	1ST YR	.043	.018	.029	.015	.013
	2ND YR	.088	.027	.049	.039	.037
	5YRTOT	.129	.049	.075	.078	.057
Italy	1ST YR	.050	.009	.029	.043	.013
	2ND YR	.102	.016	.049	.075	.039
	5YRTOT	.124	.030	.065	.118	.050
Netherlands	1ST YR	.043	.026	.020	.055	.016
	2ND YR	.091	.038	.038	.092	.042
	5YRTOT	.125	.064	.054	.148	.060
United Kingdom	1ST YR	.053	.007	.018	.028	.009
	2ND YR	.107	.014	.034	.056	.033
	5YRTOT	.132	.025	.045	.091	.041
Rest of OECD	1ST YR	.035	.008	.019	.050	.025
	2ND YR	.070	.015	.035	.082	.050
	5YRTOT	.130	.031	.061	.148	.088
Non-OECD	1ST YR	.060	.006	.018	.028	.022
	2ND YR	.108	.012	.033	.054	.048
	5YRTOT	.150	.024	.050	.096	.074

Source: Adapted from Centraal Planbureau (1975, p. 46).

TABLE 9

MINI-METEOR SIMULATION OF EFFECTS OF DOMESTIC PRICE CHANGES ON DOMESTIC PRICES

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

		United States	Belgium	France	Germany	United Kingdom
Canada	1ST YR	.009	0.000	.001	.002	.002
	2ND YR	.040	.002	.004	.008	.006
	5YRTOT	.176	.007	.017	.031	.025
United States	1ST YR	1.270	0.000	0.000	.001	.001
	2ND YR	.353	.001	.002	.003	.002
	5YRTOT	1.459	.004	.010	.019	.014
Japan	1ST YR	.004	0.000	.001	.001	.001
	2ND YR	.017	.001	.003	.005	.004
	5YRTOT	.077	.001	.006	.011	.008
Belgium	1ST YR	.005	1.313	.008	.011	.004
	2ND YR	.026	.405	.025	.036	.014
	5YRTOT	.126	1.629	.062	.106	.046
France	1ST YR	.004	.002	1.354	.005	.002
	2ND YR	.015	.006	.481	.015	.006
	5YRTOT	.090	.018	1.708	.054	.022
Germany	1ST YR	.002	.002	.003	1.358	.001
	2ND YR	.014	.005	.008	.480	.005
	5YRTOT	.092	.016	.025	1.728	.018
Italy	1ST YR	.005	.001	.004	.005	.002
	2ND YR	.022	.004	.012	.017	.007
	5YRTOT	.099	.013	.032	.054	.023
Netherlands	1ST YR	.008	.005	.004	.011	.004
	2ND YR	.031	.015	.014	.034	.013
	5YRTOT	.111	.037	.039	.091	.038
United Kingdom	1ST YR	.006	.001	.002	.004	1.356
	2ND YR	.024	.003	.008	.013	.522
	5YRTOT	.106	.009	.021	.039	1.836
Rest of OECD	1ST YR	.005	.001	.004	.009	.005
	2ND YR	.021	.005	.011	.027	.014
	5YRTOT	.109	.016	.035	.081	.045
Non-OECD	1ST YR	.006	.001	.002	.003	.002
	2ND YR	.016	.002	.005	.008	.007
	5YRTOT	.032	.006	.011	.019	.015

Source: Adapted from Centraal Planbureau (1975, p. 49).

are all positive and increase through time. In general, these effects are relatively small, with the largest entries occurring for countries with the closest trading ties (Canada with the U.S. and Germany with other members of the European Community). A similar pattern is evident for the cross-country effects on domestic prices, indicated in Table 9. The own-country effects show evidence of cyclical behavior.

In order to provide some guidance on the responsiveness of domestic prices to changes in import prices that are foreign induced, we have calculated the cross-country ratios of Table 9 to 8. The resultant "elasticities" are thus a rough measure of foreign price-transmission effects via import prices that may be attributed to exogenous price increases in the countries listed at the top of the table.

TABLE 10

MINI-METEOR SIMULATION OF EFFECTS OF DOMESTIC PRICE CHANGES

(Ratio of percentage domestic price change to percentage import price change of country in row induced per unit percentage price change of country in column)

		United States	Belgium	France	Germany	United Kingdom
Canada	1ST YR	.07	.00	.11	.12	.13
	2ND YR	.22	.22	.19	.21	.36
	5YRTOT	.73	.35	.46	.39	.38
United States	1ST YR		.00	.00	.04	.06
	2ND YR		.08	.08	.06	.05
	5YRTOT		.19	.31	.22	.24
Japan	1ST YR	.05	.00	.09	.05	.08
	2ND YR	.11	.11	.12	.11	.09
	5YRTOT	.53	.07	.43	.20	.24
Belgium	1ST YR	.15		.21	.20	.21
	2ND YR	.36		.40	.40	.33
	5YRTOT	.99		.63	.68	.64
France	1ST YR	.09	.11		.10	.13
	2ND YR	.15	.21		.18	.15
	5YRTOT	.70	.36		.40	.39
Germany	1ST YR	.05	.11	.10		.08
	2ND YR	.16	.19	.16		.14
	5YRTOT	.71	.33	.33		.32
Italy	1ST YR	.10	.11	.14	.12	.15
	2ND YR	.22	.25	.24	.23	.18
	5YRTOT	.80	.43	.49	.46	.46
Netherlands	1ST YR	.19	.19	.20	.20	.25
	2ND YR	.34	.39	.37	.37	.31
	5YRTOT	.89	.58	.72	.61	.63
United Kingdom	1ST YR	.11	.14	.11	.14	
	2ND YR	.22	.21	.24	.23	
	5YRTOT	.80	.36	.47	.43	
Rest of OECD	1ST YR	.14	.13	.21	.18	.20
	2ND YR	.30	.33	.31	.33	.28
	5YRTOT	.84	.52	.57	.55	.51
Non-OECD	1ST YR	.10	.17	.11	.11	.09
	2ND YR	.15	.17	.15	.15	.15
	5YRTOT	.21	.25	.22	.20	.20

Source: Based upon Tables 8 and 9.

The wage-rate simulations, which are not reproduced here, result in positive own- and cross-country effects. It is interesting that the own-country price effects of domestic price increases are all substantially larger than the effects of wage increases, while the cross-country effects are just the opposite. Thus, the mini-METEOR simulations suggest that the transmission effects on domestic prices are greater from exogenous increases in wages than from exogenous increases in domestic prices. The difference apparently stems from the relatively more favorable effects that wage increases in the model have in terms of increasing productivity and reducing unemployment.

COMET

The simulation results of an exogenous 5 per cent increase in the German wage rate, under conditions of fixed exchange rates, are shown in Table 11. While the initial impact was relatively small,

TABLE 11

SIMULATION RESULTS OF AN EXOGENOUS 5 PER CENT INCREASE IN THE GERMAN WAGE RATE IN 1973, BASED UPON THE COMET MODEL

(Percentage change)

Country	Year	Wage Rate	Private Consumption Deflator	Import Prices
		(1)	(2)	(3)
Germany	1973	6.8	1.5	−0.0
	1980	10.7	7.8	1.2
France	1973	0.4	0.1	0.1
	1980	4.8	2.6	0.5
Italy	1973	0.3	0.2	0.1
	1980	11.3	8.1	1.0
Netherlands	1973	0.1	0.2	0.1
	1980	19.2	10.2	0.7
Belgium-Luxembourg	1973	0.2	0.1	0.2
	1980	8.9	3.7	2.6
United Kingdom	1973	0.1	0.0	0.1
	1980	2.0	0.7	1.5
Ireland	1973	0.2	−0.0	0.1
	1980	5.4	0.3	1.1
Denmark	1973	0.1	0.0	0.2
	1980	4.5	2.8	0.8

Source: Adapted from Barten *et al.* (1976, p. 104).

TABLE 12

COMET: REGRESSION RESULTS FOR DEFLATOR FOR PRIVATE CONSUMPTION

	α_0	k	α_1	α_2	α_3	β	ξ	R^2	s	DW
D	1.217	0.287	0.836	0.070	0.094	−0.01 [a]	0.219	0.795	0.0054	2.19
F	4.014	0.838 [b]	0.795	0.145	0.060	−0.01 [a]	0.108	0.781	0.0123	1.59
I	2.110	0.495	0.906	0.020 [a]	0.074	−0.070	—	0.858	0.0081	2.31
N	1.815	0.517	0.691	0.019 [a]	0.290	−0.019	—	0.864	0.0078	2.56
B	1.626	0.490	0.653	0.080	0.266	−0.018	—	0.702	0.0114	1.90
UK	2.295	0.548	0.826	0.018 [a]	0.156	−0.01 [a]	—	0.918	0.0052	2.15
IR	1.788	0.331	0.513	0.336	0.151	−0.025	—	0.834	0.0085	1.85
DK	1.518	0.448	0.662	0.022 [a]	0.316	−0.01 [a]	0.391	0.603	0.0120	1.19

[a] Assigned coefficient value.

[b] For simulation purposes this coefficient has been set at 0.538, and the constant adjusted at 2.258.

The estimated equation is:

$$\Delta \ln PC_t = \alpha_0 + k[\alpha_1 \ln (WR \cdot N_t/YO_t) + \alpha_2 \ln V_t + \alpha_3 \ln PMG_t + ITR_t - \ln PC_{t-1}] + \beta[\ln (1 - DUC_t/100 - \xi \ln (1 - DUC_{t-1}/100] + \xi \Delta \ln PC_{t-1} + e_t$$

where

PC = Deflator for private consumption
WR = Wage rate
N = Total employed labor
YO = GNP
V = Capital user's cost
PMG = Price index of goods imports
ITR = Ratio of indirect taxes minus subsidies to GNP
DUC = Degree of capacity utilization
k is speed of adjustment; t is time; e is the error term; $\alpha_0 - \alpha_3$, β, and ξ are parameters.

Source: Adapted from Barten *et al.* (1976, p. 112).

there were evidently substantial increases especially in the wage rate and private consumption deflator for Italy, the Netherlands, and Belgium-Luxembourg. It is noteworthy that the corresponding increases in import prices were much smaller particularly in Italy and the Netherlands. Comparatively small increases in import prices relative to the wage rate and private consumption deflator were evident also for France and Denmark.

The direct transmission of foreign price changes through import prices thus appears to be relatively much less important in the COMET model than the effects that occur indirectly. Some indication of the importance of the direct and indirect effects can be seen in Table 12, which summarizes the regression results for the determinants of the deflator for private consumption. The elasticity with respect to unit labor costs (α_1) is substantially greater than the elasticity with respect to import prices (α_3).

IV. Conclusion

It is still something of a novelty in constructing theoretical macroeconomic models for open economies to make allowance for the direct linkage of prices. Our review of some selected national and linked econometric models suggests that the econometric model builders have been very much aware of the possibility and importance of international price linkages. Although the evidence was not always clear because of the use of expenditure deflators rather than the prices of domestically produced goods, we were able to discern several empirical examples demonstrating that foreign prices in fact play a direct and important role in the determination of the prices of domestic goods and also in the determination of wages. Theoretical macroeconomic models that abstract from international price linkages may thus constitute an unacceptable simplification of reality.

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REFERENCES

Aubry, J. P. and H. Kierzkowski. "The Transmission of Foreign Price Inflation under Alternative Exchange-Rate Regimes: A Review of Recent Theoretical Developments and Experiments with RDX2 and MPS," presented to the Third International Conference on Applied Econometrics, European Community Commission, Brussels, February 1976.

Aukrust, O. "Inflation in the Open Economy: The Norwegian Model," *Working Papers from the Central Bureau of Statistics of Norway*, 1975.

Barten, A. P., G. d'Alcantara, and G. J. Carrin. "COMET: A Medium-Term Macro-economic Model for the European Economic Community," *European Economic Review*, 7 (1976).

Branson, W. H. *Macroeconomic Theory and Policy*. New York: Harper and Row, 1972.

Branson, W. H. "Monetarist and Keynesian Models of the Transmission of Inflation," *American Economic Review*, 65 (May 1975), pp. 115-119.

Calmfors, Lars. "A Two-Sector Model for Inflation and Unemployment in a Small Open Economy," Institute for International Economic Studies, University of Stockholm, Seminar Paper No. 59, October 1976.

Calmfors, Lars and Jan Herin. "Price Formation in Open Economies: A Case Study of Sweden," Institute for International Economic Studies, University of Stockholm, Seminar Paper No. 77, April 1977.

Caprio, G., Jr. *The International Transmission of Inflation in the Short Run*. Unpublished doctoral dissertation, University of Michigan, 1976.

Centraal Planbureau. "Mini-METEOR: A Simple Multi-Country Simulation Model," processed, The Hague, June 30, 1975.

Deardorff, A. V. "A Framework for Analysis in International Macroeconomics," *Weltwirtschaftliches* Archiv, 113 (1977), pp. 209-236.

Deardorff, A. V. and R. M. Stern. "International Economic Interdependence: Evidence from Econometric Models," Seminar Discussion Paper No. 71, Research Seminar in International Economics, University of Michigan, January 28, 1977.

Edgren, G., K-O. Faxén and C-E Odhner. *Wage Formation and the Economy*, London, 1973.

Frenkel, J. A. and H. G. Johnson, eds. *The Monetary Approach to the Balance of Payments*, Toronto: The University of Toronto Press, 1976.

Johnson, K. N. and L. R. Klein. "Stability in the International Economy: The LINK Experience," in A. Ando *et al.* (eds.), *International Aspects of Stabilization Policies*, Conference Series No. 12, Federal Reserve Bank Boston, 1974.

Machlup, Fritz. *International Trade and the National Income Multiplier*, Philadelphia: The Blakiston Co., 1943.

Metzler, Lloyd A. "Unemployment Equilibrium in International Trade." *Econometrica*, 10 (April 1942).

Mundell, Robert A. "Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates," *Canadian Journal of Economics and Political Science*, 29 (November 1963), pp. 475-485.

Mundell, Robert A. *International Economics*, New York: Macmillan, 1968.

Stern, R. M. *The Balance of Payments*, Chicago: Aldine Publishing Co., 1973.

Tsiang, S. C. "The Role of Money in Trade-Balance Stability: Synthesis of the Elasticity and Absorption Approaches," *American Economic Review* 51 (December 1961).

Turnovsky, S. I. and A. Kaspura. "An Analysis of Imported Inflation in a Short-Run Macroeconomic Model," *Canadian Journal of Economics*, VII (September 1974).