

NBER WORKING PAPER SERIES

TRADE STRUCTURE AND TRANSMISSION OF INFLATION:
THEORY AND JAPANESE EXPERIENCE

Jongmoo Jay Choi

M. Ishaq Nadiri

Working Paper No. 923

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

June 1982

The research reported here is part of the NBER's research program in International Studies. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

Trade Structure and Transmission of Inflation:
Theory and Japanese Experience

ABSTRACT

The international price linkage in a single commodity model can be explained trivially by the law of one price or the quantity theory of money. In this paper, we formulate a simple sectoral, general equilibrium model with money. The transmission of price pressures from the world market to nontradable sectors of a domestic economy depends on industry structure, and the size of the direct price substitution effect and the indirect money and income effect through the balance of payments. The structural model is then empirically implemented for Japan, 1956-77. Various dynamic simulations conducted show both the overall magnitude of imported inflation and the relative importance of three major channels of transmission (price, money and income) in Japanese inflation during the period covered. These results imply that closing of one channel of transmission such as the monetary channel by a completely sterilizing monetary policy does not insulate the domestic economy from foreign price disturbances.

Jongmoo Jay Choi
c/o National Bureau of
Economic Research
269 Mercer Street, 8th Floor
New York, NY 10003

M. Ishaq Nadiri
National Bureau of Economic Research
269 Mercer Street, 8th Floor
New York, NY 10003

(212) 598-7042

"Imported" inflation has been the subject of increasing concern but not enough attention has been given to how the structure of the economy affects the nature and process of the transmission of inflation. Many models of inflation in an open economy [Brunner and Meltzer (1977), Parkin (1977), Laidler (1976), Branson (1975), Turnovsky and Kaspura (1974) and others] either combine "domestic" and "foreign" factors in an ad hoc manner or rely on aggregate real-sector modelling. The aggregate, one-commodity approach, however, conceals the forces that lie behind sectoral transmission of price pressures. The international price linkage in a single commodity model can be explained trivially by the law of one price or by the quantity theory of money. The transmission of inflation from the world market to a domestic economy, however, is inherently a two-stage process: first, the direct linkage between the world market and the tradables sector of the domestic economy, and second, the subsequent spillover to the nontradables sector.

The sectoral, multi-commodity approach is, of course, basic in international trade literature, but its implication for the price linkage is yet to be explored fully. As pointed out by Jones and Corden (1976), in a relative-price model of tradables and nontradables, devaluation cannot improve home balance of trade without creating an excess demand in nontradables sector. The inflationary pressure created in the nontradables-- unless offset by government anti-inflation efforts specifically addressed to this market--underscores a necessity for a more general analysis which includes the income and money as well as the relative price effect.

The Scandinavian theory of inflation [Aukrust (1970), Edgren, Faxen and Odhner (1969)] recognizes the importance of the structural problem, but the transmission in that model is entirely supply-determined, contingent on the

assumption of constant factor shares and constant mark-up.¹ A recent paper by Katseli-Papaefstratiou (1980) emphasizes consumption substitution in the transmission of inflation, but in a framework where the monetary channel connecting the balance of payments and the money supply is not recognized.

The purpose of this paper is two-fold: first, to construct a simple model of international price linkage for an open economy which incorporates both the direct price channel due to substitution in production and consumption, and the indirect channel through the impacts of the balance of payments on the money supply and income. The transmission of inflation from the world market to a domestic economy is viewed as a two-stage process: first, the direct linkage between the world market and tradables sector of the economy, and, second, the subsequent spillover to the nontradables sector. The theoretical analysis suggests a possible conflict between the direct and the indirect effects, and emphasizes the importance of the structure of the economy in international transmission of inflation.

Second, the structural model suggested in the theoretical analysis will be implemented empirically for Japan and simulated dynamically for the effect of various foreign shocks. Estimation is on annual data from 1956 to 1977. Japan is an interesting and fitting case, because its trade structure is easily identifiable and because its capital account is basically dictated by the trade balance--thus effectively exogenous as in our model--rather than the other way around. The debate on the relative price behavior of primary versus manufactured commodities in the world market, coupled with dependence on raw material imports and exports of finished products within the export-led growth strategy, provides an added reason for interest in the Japanese experience. "Partial" simulations will also

be attempted to highlight the relative importance of the three major channels of transmission--price, money and income--in Japanese inflation. The results suggest that closing of one channel of transmission such as the monetary channel by complete sterilization by the monetary authority, does not insulate the domestic economy completely from foreign price disturbances.

1. The Model

Our model is a monetary general equilibrium framework with tradables, nontradables and money. To allow for an exogenous change in external terms of trade, tradables are further divided into importables and exportables, but overall categorization of tradables versus nontradables is maintained, that is, substitution is between tradables--or one kind of tradables--and nontradables, not within the tradable goods. Such specification permits focusing attention on the "exposed" versus "sheltered" sector distinction often stated in the literature, which is important for our present purpose.²

The model focuses on the linkage between the world prices of tradables and the domestic prices of nontradables through commodity trade for a small country case under the fixed exchange rate regime. A price increase in the world market is first imported to domestic tradables sector of the economy through commodity arbitrage. The resulting increase in price of tradables relative to nontradables then triggers substitution of consumption from the former to the latter. Productive resources, on the other hand, will shift from nontradables to tradables. On both counts, the prices will increase in the nontradables sector. Further there is an indirect channel through the balance of payments. The relative-price change affects the balance of trade, which, given exogenous private capital flows, will affect the money

supply and income. The price of nontradables will be affected accordingly.

We assume that capital flows, world prices of tradables, and the exchange rates are exogenous; exogeneity of capital flows is a minor problem in Japan, since, over the period of empirical work, the Japanese government had de facto controls over capital flows. The "small country" assumption, especially with respect to export prices, may prove a bit troublesome. However, for the interest of volume growth, the Japanese generally are known to be reluctant in using their potential monopoly power to raise export prices in the world market. The assumption of fixed exchange rates potentially is a serious problem for the latter half of the period under consideration. This assumption was dictated by our choice of annual data in view of our interest in structural issues in this paper. Experiments under the fixed-rate assumption, however, are still of relevance, since the yen experiences in the 1970s were marked as much by the "exogenous" government interventions--which can be accommodated in the present model--as the free market forces. The fact that Japanese balances of payments were nowhere near zero during this period testifies that the real-world "managed floating" after 1972 in Japan includes a high--even dominant--element of "fixed" exchange rate regime. A dummy variable is included in the empirical model to capture implications of different exchange regimes.

Suppose a domestic supply, Q^i of commodity i -- $i=n$ and t denoting nontradables and tradables respectively, with the latter including importables (z) and exportables (x)--that is a simple positive function of the amount of inputs engaged in production process (F^i) and the productivities of such inputs (PR). Total factor employment is assumed to be demand-

determined, hence a negative function of its own input prices (q).³ Sectoral employment, however, is also influenced by business conditions in that sector relative to others, measured by output prices. The signs beneath the equation show the expected signs of the partial derivatives of the dependent variable with respect to each argument.⁴

$$(1a) \quad Q^n = Q^n [F^n (P^n, P^t, q), PR] \quad \begin{matrix} Q_1^n > 0, & Q_2^n > 0, & F_1^n > 0, & F_2^n < 0, & F_3^n < 0 \end{matrix}$$

$$(1b) \quad Q^t = Q^t [F^t (P^t, P^n, q), PR] \quad \begin{matrix} Q_1^t > 0, & Q_2^t > 0, & F_1^t > 0, & F_2^t < 0, & F_3^t < 0; & t=z, x \end{matrix}$$

Domestic demand for a commodity (D^i) is of standard form: negatively related to its own price (P^i) and positively related to the prices of substitutes and to money income (y). Commodities are assumed to be gross substitutes and normal goods.⁵

$$(2a) \quad D^n = D^n (P^n, P^t, y) \quad \begin{matrix} D_1^n < 0, & D_2^n > 0, & D_3^n > 0 \end{matrix}$$

$$(2b) \quad D^t = D^t (P^t, P^n, y) \quad \begin{matrix} D_1^t < 0, & D_2^t > 0, & D_3^t > 0; & t=z, x \end{matrix}$$

Both the demand and supply equations are assumed to be homogeneous of degree zero, so that prices and income can be defined either real or nominal. Since the price linkage is the present objective and since the foreign exchange rates are not meaningfully defined other than between two money prices, we will take money prices and money income as our arguments in these equations.

An equilibrium in nontradables requires

$$(3) \quad Q^n (..) = D^n (..).$$

The supply and the demand in tradables, however, need not balance, the difference being the balance of trade. Since the world supply of the

country's importables (Z^S) is assumed to be infinitely elastic at given world price P^Z^* , actual equilibrium imports (Z) can be written in a similar form as home import demand, $Z^d = D^Z(\dots) - Q^Z(\dots)$.

$$(4) \quad Z = Z(P^Z, P^n, y, q, PR) \quad Z_1 < 0, Z_2 > 0, Z_3 > 0, Z_4 > 0, Z_5 < 0$$

Supposing foreign demand for exportables is a positive function of foreign income Y^* , then equilibrium export (X) similarly is

$$(5) \quad X = X(P^X, P^n, y, q, PR, Y^*). \quad X_1 > 0, X_2 < 0, X_3 < 0, X_4 < 0, X_5 > 0, X_6 > 0$$

The balance of payments (BP) equation combines these trade equations with net unilateral transfers (NF) and capital flows exclusive of official transactions (CF).

$$(6) \quad P^X X(\dots) - P^Z Z(\dots) + NF + CF = BP$$

The aggregate goods market condition implied by equations (3) and (6) is

$$\sum P^i Q^i - \sum P^i D^i + NF = CA \quad i = n, t$$

where $CA = BP - CF$ is the current account.

The equilibrium condition in money market consists of the simple quantity theory equation adjusted for an open economy according to the monetary approach to the balance of payments. Nominal demand for money is directly related to money income (y) by the Cambridge k , and the money supply includes both domestic (H) and international components (R) of the monetary base. We abstract from the role of interest rate in the demand for money.

$$(7) \quad ky = m(H + sR) \quad 0 \leq s \leq 1$$

The coefficient, "m" is the money multiplier linking the monetary base to the money supply, and "s" represents the differing degrees of sterilization by the monetary authorities. Limiting cases are of interest: $s=0$ depicts complete sterilization which is often assumed implicitly by the Keynesian analyses, while $s=1$ is the case of no sterilization, assumed in the mone-

tary approach. Equation (8) spells out the identity between the change in international reserves and the balance of payments (BP).

$$(8) \quad R_t = R_{t-1} + BP_t$$

The last equation in the system relates international and domestic prices of tradables, given the exchange rate--the price of foreign currency in terms of domestic money (e)--and trade impediment factor g .

$$(9) \quad p^t = e p^{t*} g \quad t = x, z$$

If the g is taken to be constant, then there exists a one-to-one correspondence between the world and the domestic prices of tradables. No such relationship exists for nontradables, in contrast to the monetarist models where the law of one price implicitly is extended to all goods.

The model presented above is a simple, but fairly comprehensive one, which includes both the direct price effect due to substitution in consumption and production and the indirect money and income effects through the balance of payments. Our approach is in contrast to the single-channel treatment generally seen in the existing literature on international inflation [See Krause and Salant (1977), for instance, for survey of this literature]. Yet, the model adopts several salient features of the existing models described in the literature. The characteristics of the Scandinavian model are retained in our model by sectoral disaggregation of the economy and inclusion of the supply-side effects. The element of the monetary approach to balance of payments is recognized in our money-supply equation which includes international component of money supply. A Keynesian spirit can be found in the sterilization possibility recognized as well as in the tradable-goods equilibrium which incorporates net exports.

The system can be summarized by three equations describing the equilibrium in nontradables (equation 3), the balance of payments (equation 6), and the money-market equilibrium (equation 7), plus the commodity arbitrage equation for tradables (equation 9). The price of tradables in (9), however, can be substituted in domestic demand and supply equations underlying (3) and (6). With total differentiation, the system can be solved for changes in money income (y), money price of the nontradables (P^n), and the balance of payments (BP) under the fixed exchange rate system. Capital-account variables (N^F , C^F) are taken as given. Exogenous variables consist of both international (P^Z *, P^X *, Y^*) and domestic (H, q, PR) characters.

The elasticities of the price of nontradables with respect to three foreign variables in the reduced-form solution are:⁶

$$E(P^n, P^{X*}) = \frac{P^X \frac{dP^n}{dP^X}}{AP^n} = \frac{P^X}{AP^n} [k e g N^X + m s B e g N^X - m s D_y^n e g (P^X X_{p^x} + X)] > 0,$$

$$E(P^n, P^Z) = \frac{P^Z}{AP^n} [k e g N^Z + m s B e g N^Z + m s D_y^n e g (P^Z Z_{p^z} + Z)] > 0 \text{ if } |E(Z, P^Z)| > 1,$$

otherwise indeterminate,

$$\text{where } A = (k + m s B) (D_p^n - Q_F^n N_F^n) + m s D_y^n (P^X X_{p^n} - P^Z Z_{p^n}) < 0,$$

$$B = -(P^X X_y - P^Z Z_y) > 0, N^X = Q_F^n N_F^n - D_p^n < 0, \text{ and } N^Z = Q_F^n N_F^n - D_p^n < 0.$$

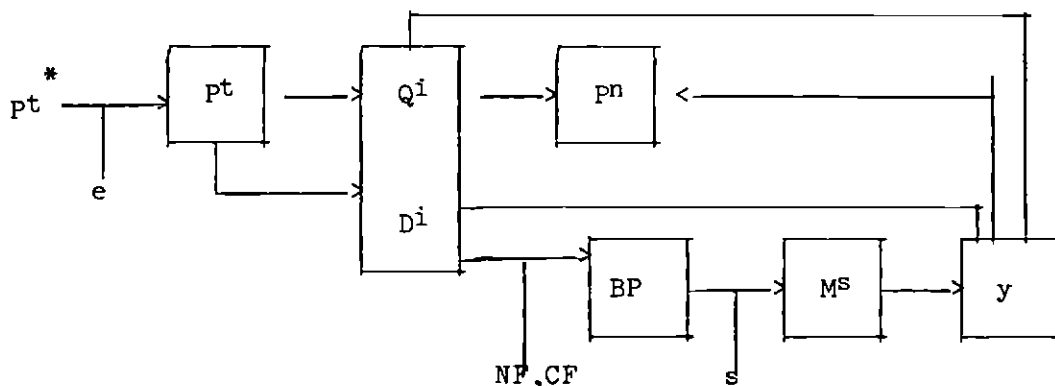
Subscripted variables indicate partial derivatives.

A rise in the world price of tradables directly causes a rise in the domestic price of tradables through the law of one price given the trade barriers and the exchange rates. This rise in the domestic price of

tradables will then be spilled over to the nontradables sector both through the direct price channel due to substitution in consumption and production between sectors, and through the indirect channel through changes in the balance of payments, the money supply and income.

In the price elasticity formulae, the first terms which contain N^t , $t=x$ and z , reflect the direct impact spillovers from tradables to nontradables due to the price effect of substitution in consumption and production. The third terms represent the indirect effects that operate through the balance of payments (the bracketed term), the money supply (ms), and income (D_y^n). The middle terms, with both N^t and B in the expression, reflect general-equilibrium consequences of the direct impact spillovers: a rise in the price of nontradables as a result of the direct spillover from the tradables due to substitution may affect the balance of payments, which--following the money/income channel--may in turn affect the price of nontradables. This contrasts with the indirect effects which start with an initial increase in the price of tradables. A pictorial view of the chains of transmission in the case of the fixed exchange rate system is provided in figure 1. Endogenous variables are in the boxes. Exogenous or policy variables which can intervene in the transmission process are shown without the boxes.

FIGURE 1



Several interesting points emerge. First, the overall impact of transmission depends on the relative size of the direct and the indirect effects. The direct price spillovers through substitution are positive, but the indirect effects depend on demand elasticity. When import demand is elastic, the indirect price effects are positive. With inelastic demand, however, the indirect effects on nontradables *ceteris paribus* are negative. The overall impact on the price of nontradables, therefore, depend on the demand-reducing (hence deflationary) effect of the balance-of-payments deterioration, and the demand-increasing and the supply-reducing (hence inflationary) effects in the nontradables market due to consumption and production substitution.

With elastic import demand, the indirect effect (of a change in the price of the importables) reinforces the direct price effect, but offsets it when import demand is inelastic.⁷ The conclusion from the conventional one-commodity transmission model which, by definition, predicts uni-directional price changes is supported only when import demand is elastic. This highlights the importance of the industry structure--tradables and nontradables--in the transmission of inflation, insofar as the indirect effects depend on the import demand elasticity, and the general level of prices is a weighted average of the two different sectoral prices.⁸

Second, the case of an increase in foreign income is a special one in that it involves the indirect channel of adjustment only: there is no direct impact spillover due to substitution (or the general equilibrium consequences of it naturally). The effect in this case is straightforwardly positive on the price of nontradables.

$$E(P^n, y^*) = \frac{y^*}{AP^n} (-msD^n P^X X_{y^*}) > 0,$$

Finally, in the same spirit, even complete sterilization of the balance-of-payments pressures by the monetary authority ($s=0$) cannot "insulate" the domestic economy completely as far as the prices are concerned. The direct spillovers from tradables to nontradables due to substitution are still possible. Further, due to the removal of an uncertain indirect effect term which depends on demand elasticities, the effect of a change in p^t on p^n is now unambiguously positive. Importation of foreign inflation can be mitigated with complete sterilization,⁹ but not prevented completely, since the direct price channel is still very much alive.¹⁰ The "insulation" of the nontradables sector by these institutional schemes is found to be a special case where there is only one commodity, or where the substitution effect is ruled out.¹¹

2. An Empirical Application

In this section, the structural model suggested in the theoretical analysis will be implemented empirically for Japan using the annual data from 1956 to 1977. While modifications were necessary in individual equations to conform to Japanese realities, the overall empirical system basically matches the theoretical construct in all important respects. In particular, the system contains, as required, three major channels of transmission both over time and across equations. A potentially difficult problem of identifying the industry structure turns out to be not difficult: Japanese exports are almost entirely manufactured goods and over 80% of all imports are primary commodities. Services, and products from other tertiary industries in national income accounting, plus construction, are defined nontradables.

Estimation is done by the ordinary least square or the Cochrane-Orcutt regression method. In the case of the latter, indicated by the presence of an autocorrelation coefficient, ρ , a specification of the lag structure is required in system solution. The full empirical model is provided in Appendix I. Definitions and the data sources of the variables are in Appendix II.

The system consists of four sectors. The first direct price-linkage sector relates the world prices of Japanese exportables and importables to the domestic prices of the same commodities. This is done in two steps: first, through the "law of one price" equations estimated in logarithmic form, and, second, through the bridge equations connecting the domestic prices of actual imports and exports with those of import-competitive products (primary industry) and potential exports (manufacturing industry).

In the foreign trade sector, real goods import is a log-linear function of the relative price between imports and nontradables, real wage rate, the foreign exchanges available from goods and services exports plus net transfers and capital flows, and the oil shock dummy. Inclusion of the available foreign exchanges reflects an observation that the Japanese economy has grown basically export-dependent. This takes a role of income variable left out due to its domination of the relative price term which is important in our context. The magnitude of the coefficient of the relative price term indicates that Japanese import demand is in fact inelastic due to her dependence on raw material imports. Exports are estimated directly in value form; a real export equation performs poorly. Arguments included are foreign income measured by the trade-weighted index of real GDP's in developed (Japan excluded) and developing market economies as aggregated in

U.N., Yearbook of National Accounts Statistics, the price ratio between exportables and nontradables, and the 1973-74 oil-shock dummy. Real domestic GDP is also included to capture negative domestic demand pressure.

In the monetary sector, the money supply comes from the monetary reserves of both domestic--exogenously controlled by the monetary authority--and international--related to the balance of payments--sources. The elasticity of the money supply, M_1 , with respect to reserve is rather low (0.37) in the short run but unity in the long run. The usual demand-for-money function, which includes the interest rate as its argument, is not included for two reasons: it is difficult to implement empirically in Japan and it is not important in our theoretical analysis. Following the convention in Japanese macro econometric modelling,¹² the real and the financial sectors are linked, instead, through domestic credit. In addition, a dummy variable is included to measure possible structural changes since the start of the flexible exchange rate system in the 1970s.¹³

Finally, the domestic sector determines real income and the price of nontradables. The real income depends on domestic credit and imports of goods and services--which represent two important factors for Japanese growth as most Japan-observers would agree--plus a post oil-shock dummy and a lag. The income equation should be viewed as an equilibrium condition where the real balance of domestic credit is a shift (increase) parameter in aggregate demand, and where increased access to imported materials similarly boosts the aggregate supply. This specification of an equilibrium output would appear to be more satisfactory than the usual hypothesis of demand-determined (for developed economy) or supply-determined economy (for developing economy), given the fast-track growth of Japan in the post-war period. This takes us a bit out of the theoretical specification, but

enables us to identify the income (output) channel of transmission separated from the monetary channel, which would not have been possible with a pure demand-determined income equation.

A change in income affects the price of nontradables through the wage rate. The wage rate depends on the general level of prices--the GDP deflator-- and the real GDP reflecting general activity level. The real GDP is used in lieu of the conventional demand-supply gap measures such as unemployment rate or the capacity utilization rate. The conventional measures are thought to be relatively unimportant in Japan, the reasons being the importance of "life contracting" in the labor market, and the high and fairly steady growth of the Japanese economy in this period. In any event, the wage rate is but an intermediary in the indirect channel of transmission, connecting the income and the price of the nontradables.

3. Simulation Results

The model performs fairly well in its ability to track the Japanese experience during the period under consideration. Mean absolute errors for the 14-year simulation period (1963-1976) are 1.5% for the price of nontradables and 2.0% for the GDP deflator. Indeed, errors are rather small if one considers that the model is basically a "transmission" model without a fully-developed domestic sector, and that the present simulation includes volatile years of the 1970s.

The model can be simulated for the impacts of various "foreign" shocks. The control solution is obtained by solving iteratively the dynamic system after storage of the single-equation residuals as additive adjustments in the constant term. The storage of residuals enables us to impose the shock in the vicinity of real world numbers, which is important in a non-linear

system such as the present one since the system response to a shock may not be independent of initial values.

We experiment with three "foreign" shocks: (a) a 10% increase in the world price--in the U.S. dollars--of Japanese imports; (b) a 10% increase in the world price of Japanese exports; and (c) a 1% increase in the level of real GDP in foreign countries, computed as a Japanese trade-weighted average of index of real GDP's in developed and developing regions of the world. In addition, a series of "partial" simulations were experimented with an eye on highlighting the differential impact of each channel of transmission. All shocks were exogenous, and were sustained over the simulation period. The shocks were computed as percentage deviations rather than absolute deviations, to minimize the impact of volatility in the underlying series.

The theoretical analysis suggest that, under the fixed exchange rates, the general level of domestic prices is affected by a rise in the world prices of the country's importables in the following ways:

- (a) positively, due to an increase in domestic prices of importables via commodity arbitrage, and entry of these items in the general price index;
- (b) positively, as a result of an impact spillover of the price pressures from tradables (importables) to nontradables due to consumption and production substitution via the direct price channel; and
- (c) positively or negatively, depending on whether import demand is elastic or inelastic, as a result of an improvement or deterioration of the balance of payments, and the resulting increase or decrease in

the money supply and income, in the absence of effective offsetting government policy.

The overall effect, therefore, is unambiguously positive if import demand is elastic. With inelastic import demand, however, there is uncertainty on the direction of the change in the price of nontradables with a rise in import prices, depending on the relative strength of the spillover due to the direct price effect--(b)--and the deflationary forces of the balance-of-payments deficits due to the indirect money and income effects--(c). The same possibility exists for the general level of prices, but the presumption here is much stronger towards a positive effect, owing to the direct entry of imported consumer goods in the price index--(a).

The introduction of a supply shock facilitates separation of the supply-determined output/income effect from the demand-determined money effect. It, however, complicates the analysis further. Barring Giffen goods, real imports (of foreign inputs) will fall with a rise in the price of foreign inputs which would--through the production function--reduce the real GDP. But, the value of imports will decrease or increase according to whether import demand for foreign inputs is elastic or inelastic, hence the effect on the balance of payments, real income, and prices are in general uncertain.

The simulation results for 1963-76 with the three exogenous shocks are provided in Table 1. The numbers in the table are the percentage deviations between the shocked and the control solutions, and can be viewed as elasticity multipliers--percentage changes in domestic prices by unit percentage changes in the shocked foreign variables. The results from the import-price shock confirm that Japanese import demand is inelastic with

Table 1: Simulated Effect of Exogenous Foreign Shocks
(Percentage Changes)

	<u>10% Import Price Increases</u>		<u>10% Export Price Increases</u>		<u>1% Foreign Income Increases</u>	
	<u>Pⁿ</u>	<u>P</u>	<u>Pⁿ</u>	<u>P</u>	<u>Pⁿ</u>	<u>P</u>
1963	0.16	0.56	0.64	2.25	-	-
1964	0.44	1.08	1.02	2.56	-	-
1965	0.55	1.41	1.24	2.56	-	-
1966	0.75	1.83	1.50	2.93	0.25	0.12
1967	0.83	1.98	1.67	3.03	0.24	0.23
1968	1.01	2.01	2.35	3.35	0.78	0.45
1969	0.98	1.92	2.82	3.74	1.19	0.75
1970	0.80	1.80	3.10	3.90	1.50	0.80
1971	0.75	1.63	3.11	3.83	1.60	0.96
1972	0.63	1.65	3.05	3.75	1.62	1.01
1973	0.65	1.39	3.09	3.69	1.55	0.90
1974	0.47	1.36	2.83	3.80	1.41	0.81
1975	0.45	1.45	2.88	3.54	1.47	0.95
1976	0.36	1.37	2.73	3.38	1.43	0.83

Notes:

Pⁿ = the price of nontradables; P = general level of prices
[see Appendix II for detailed definition and data sources]

respect to prices.¹⁴ Real GDP declines as a result of both the balance-of-payment deterioration and a fall in real imports of intermediate input.

As indicated by the net positive impacts, in the nontradables, the positive direct price spillover outweighs the deflationary effect of the balance-of-payments deterioration with a rise in import prices. However, the price changes are significantly smaller in nontradables than in the tradables, as implied by higher percentage impacts, as shown in the table, in the general level of prices than in the price of nontradables. Further, the sectoral differences are maintained over the entire simulation period. These results support what Kravis and Lipsey (1978) had found for other economies, that sectoral price differentials are both substantial and persistent, and contrast with such aggregate or the monetarist models which assume or predict long-run homogeneity in sectoral prices.

All in all, a 10% sustained increase in the world import prices brings about a 0.6% increase in general level of prices in the first year, with its peak effect reaching 2% in the sixth year. The time it takes to the peak is rather long, which probably reflects the inclusion of slow-responding production sector in our model. Effects on the price of nontradables are much lower with the impact effect of 0.2%, and the peak of 1% only. The stability of the system is evident not only in prices, but in real GDP which tends towards the original level (deviations tend towards zero), although there exhibits some fluctuation in trade figures in later years reflecting general uncertainties of the 1970s. The balance of trade remains out of balance, suggesting again a possible non-homogeneity in

sectoral price movement even in the long run when import demand is inelastic.

The effects of the export-price shock are similar to those of the import-price shock, except that the ambiguity is removed. Since the value of exports and the balance of payments would now improve, the indirect effect through the money and the income channel is unambiguously inflationary with a rise in export prices. The indirect effect now reinforces the direct effect, producing a tendency towards a long-run balance of payments equilibrium. The response patterns are sectorally more homogeneous, and the price differentials appear to be narrow over time. Due to the lack of possible deflationary effects through the worsening balance of payments, the effect on domestic prices is greater with an export price shock, than the same percentage shock in import prices.

The foreign income shock highlights a case where the direct linkage between foreign and domestic prices in tradable market, and the subsequent spillover to the nontradables through the price channel, are absent. All impacts reflect transmission through the indirect channel. Through the indirect channels, the price of nontradables, and hence the general level of prices, would rise consequently. The boost in exports would cause an increase in imports due to the improved foreign exchange situation, contributing to a gradual approach to equilibrium in the balance of payments.

An interesting point is that this indirect channel can be closed by a complete monetary sterilization. The differences between a foreign real (activity) shock and a foreign price (nominal) shock should also be noted. The former works through the money and income channels which can be stopped

by the monetary authority, but the latter works through the price as well as the money and the income channels which can be blocked only partially.

4. Partial Simulation Results

To continue on this note of differentiation among various channels of transmission, a series of "partial" simulations were carried out, i.e., the simulations with one of these channels turned off. The first "partial" experiment blocks the entry of importables and exportables to the price index. The second simulation disconnects the relationship between the international reserves and the money supply, so that the money supply is effectively exogenized. The third experiment removes the real-imports term in real-output equation; the income effect not associated with the money effect is hence closed off. These three "partial" models were simulated with imposition of 10% shocks on import and export prices.

Tables 2 and 3 report the dynamic simulation results from these "partial" experiments. In the case of an import price shock (Table 2), it is immediately clear--by the comparison with the "full" simulation results (Table 1)--that the effects on the domestic prices are minimal if the direct price channel is closed. In fact, the impacts on the price of nontradables turn negative in later years, as the deflationary effect of the balance-of-payments deterioration with inelastic import demand overtakes the small initial price spillovers.¹⁵ With closing of the monetary channel, the effects of the import-price shock are greater than under the "full" simulation, since the deflationary indirect effects are now eliminated. Similarly, the removal of the income channel facilitates the direct price impact to rise above the full simulation case, but by substantially smaller margin compared to a case when the money channel is closed. This

"perverse" result that the price impacts can be greater under partial than under full simulation arises from the fact that Japanese import demand is inelastic; the closing of the money and income channels in this case removes the deflationary effect of the balance-of-payments deterioration, hence the transmission effects are greater without them.

The relative importance of these three channels is more clearly seen in the case of an export price shock. None of the partial simulations now yield the price transmission effects which exceed those of full simulation. Table 3 presents the losses in transmission for each of the three partial simulations, as compared to the results from the full simulation. Numbers in the table are the differential price effects in the nontradables sector under partial simulations, over the results from the full simulation, for the case of 10% exogenous increase in export prices.

It is apparent that the losses are greatest if the direct price channel is closed. The price channel is especially dominant in early years, while the money and income effects are initially insignificant and gain strength over time. In the 8th year, the monetary channel--measured by losses if it is closed off--reaches a parity with the price channel. Toward the end of 14-year simulation, the monetary channel, however, declines while the price channel still retains 46% loss ratio. The income channel reaches its peak at 31% loss in the 7th year, which is significantly lower than 49% loss in the 9th year if the monetary channel is closed off. These results from partial simulations suggest that serious biases may exist in many aggregate models of transmission which do not specify the direct price channel [Darby (1978) for instance].¹⁶

Table 2: "Partial" Simulation Results of 10%
Increases in Import Prices
(Percentage Changes in the Price of Nontradables)

	<u>Price Channel Closed</u>	<u>Money Channel Closed</u>	<u>Income Channel Closed</u>
1963	0.00	0.16	0.16
1964	0.15	0.44	0.44
1965	+0.00	0.55	0.55
1966	+0.00	0.88	0.75
1967	0.00	1.07	0.83
1968	0.00	1.23	1.01
1969	-0.11	1.30	1.08
1970	-0.20	1.30	1.00
1971	-0.19	1.22	1.04
1972	-0.27	1.44	0.99
1973	-0.16	1.71	0.98
1974	-0.20	1.68	0.74
1975	-0.19	1.98	0.70
1976	-0.30	2.08	0.65

Table 3: Loss in Transmission with Partial Simulations*

	<u>Price Channel Closed</u>	<u>Money Channel Closed</u>	<u>Income Channel Closed</u>
1963	1.00	0.00	0.00
1964	0.85	0.00	0.00
1965	1.00	0.00	0.00
1966	0.83	0.08	0.00
1967	0.86	0.24	0.00
1968	0.67	0.34	0.24
1969	0.58	0.42	0.31
1970	0.52	0.45	0.26
1971	0.48	0.49	0.21
1972	0.47	0.47	0.15
1973	0.47	0.42	0.13
1974	0.47	0.33	0.07
1975	0.47	0.20	0.02
1976	0.46	0.08	0.00

* Computed as (1-partial/full simulation), for the effect of 10% export price increase on the price of domestic nontradables.

5. Summary and Conclusions

We have constructed a simple, yet comprehensive model of the price linkage between the world market and the domestic, nontradables sector which includes major balance-of-payments adjustment mechanisms. The structural equations suggested in the theoretical analysis have been implemented empirically for Japan and simulated dynamically with several "foreign" shocks.

The main theoretical conclusion is the importance of the industry structure in international transmission of inflation. The reason is the possible conflict that may exist between the direct price effect due to production and consumption substitution in nontradables sector, and the indirect money and income effects that operate through changes in the balance of payments in tradables sector. Further, depending on import demand elasticity, the two sectors may react differently to a given foreign price shock; uni-directional and homogeneous price movement implied in conventional one-commodity models is possible only when import demand is elastic, or when some sort of demand for international reserve is explicitly specified. The recognition of these different channels of transmission also proves the specialty of the alleged monetary "insulation" schemes: complete "insulation" is possible by the monetary sterilization, only when there is a single commodity, or when the direct price effect is ruled out.¹⁷

The simulation results provide some evidence of the "imported" inflation in Japan. Due to the inelastic import demand, sectoral differences in price responses to an import-price shock, however, are maintained. The prices are sectorally more homogeneous in the case of the export price

shock. The results from the more "special" case--the foreign income shock--and from "partial" simulations provide a clue on the relative magnitude of various channels in Japan. The importance of the direct price channel found underscores the possible downside bias that may be present in some existing studies where only the indirect channels--mostly the money effect at that--are specified. A foreign real shock is shown to impact differently from a foreign price shock; the former works through the indirect channels only, while the latter operates through the direct as well as the indirect channels of transmission.

The magnitude of the imported inflation estimated for Japan, however, should be qualified in terms of the several important deficiencies of the model: exogeneity of the exchange rates, and the validity of the "small-country" assumption for Japan. The theoretical section, being a comparative-static analysis, suffers from the lack of dynamics involved with the inflationary transmission. The implications of capital flows, expectations, and others can also be examined in future studies.

FOOTNOTES

1. Branson and Myhrman (1976) suggest merging the Scandinavian model with the Phillips curve. However, such a direct marriage would seem rather awkward since both cannot be the price equation; one of them should either be entirely passive or determine some other variable than price.
2. This specification is also consistent with the multi-commodity comparative advantage model, where substitution takes place between neighboring commodities only in the comparative advantage hierarchy, with nontradables in the middle separating the two kinds of tradables. This view implies that all commodities potentially are tradables except for natural and man-made trade barriers.
3. The model is not completely general since the factor prices are given exogenously. A sufficient condition for the negative sign for import prices is that factor supply is perfectly elastic at given factor prices. This assumption allows for factor unemployment.
4. Commodity definitions are given, i.e., the possibility of commodity reclassification as a result of changes in prices is not addressed in this paper.
5. The case of complementarity can easily be incorporated by changing the signs of the cross price terms.
6. The elasticities of P^D with respect to three domestic variables (H , q and PR) can be obtained likewise. The effects of q and PR depend on trade structure as do those of world prices. Interestingly, the results confirm conclusions from the Scandinavian theory in which the price in the sheltered sector is a positive function of the productivity differential between the advanced exposed--tradables--sector and the lagging sheltered--nontradables--sector. See Choi (1980).
7. No similar complications are present with respect to export prices under our assumption of elastic world market. The unit-elastic import demand will side with whichever case that has definite results. The "small country" assumption made here is actually more restrictive than necessary; all that is necessary is greater elasticity of world demand for exportables than domestic supply of exportables, and greater elasticity of world supply of importables than domestic demand for importables.
8. The importance of the industry structure is obvious with inelastic import demand since the direct and the indirect effects work in opposite directions. With elastic import demand, these two effects are of the same sign, but the industry structure would still matter as far as the general level of prices is concerned, since there is no reason to expect that the resultant change in the price of nontradables is identical to the change in the price of tradables.

9. Strictly, this is true only in terms of reduction of the number of transmission channels, since the reduced number of transmission channels does not necessarily mean a reduction in the magnitude of price pressures that are transmitted.
10. Hamada and Makoto (1978) profess a similar view in a two-country model which employs a standard supply-dominated international trade model combined with the Phillips curve.
11. The collapse of the general open-economy model to a closed-economy case requires--in addition to the balance-of-payments being zero--an assumption of a single commodity, the absence of the relative price terms in the sectoral demand and supply equations, or a discarding of the law of one price equation.
12. The Bank of Japan (1972) and the Economic Planning Agency Model of Japan [Baba and Others (1978)]. See R. Komiya and Y. Suzuki in Krause and Salant (1977); and Ackley and Ishi (1976) for discussion of Japanese institutional features.
13. A lax monetary discipline, for instance, has been suggested in the literature with the start of the flexible exchange rate regime. See Crockett and Goldstein (1976).
14. Similar results were reported by Houthakker and Magee (1969) for earlier period.
15. The effects on overall prices are still positive owing to the direct positive impact on domestic tradables.
16. Darby reports "barely detectible direct influence of foreign prices on domestic prices" for several industrial countries, but his results are contingent on having an aggregate model with a money supply reaction function.
17. Assuming, of course, that the nation continues to trade internationally. Several authors [Turnovsky (1976) and others] also suggested the same possibility -- the incomplete insulation by a monetary or exchange regime -- in other contexts, such as the role of uncertainty and information.

APPENDIX 1

The Japanese Model of Transmission of Inflation

The Direct Price Linkages

- (1) $\log p^{zt} = -4.5391 + 0.764691 \log e + 0.933346 \log p^{z*}$
 (-6.89) (6.78) (28.21)
- $R^2 = .995$ $SE = .024$ $DW = 1.90$ $\rho = .59$
- (2) $\log p^{xt} = -5.28648 + 0.904394 \log e + 0.95687 \log p^{x*}$
 (-9.22) (9.15) (18.32)
- $R^2 = .992$ $SE = .019$ $DW = 1.30$ $\rho = .85$
- (3) $p^{zn} = -0.213565 + 0.337234 p^{zt} + 0.924344 p_{-1}^{zn}$
 (-3.90) (3.15) (8.31)
- $R^2 = .973$ $SE = .079$ $DW = 2.89$
- (4) $p^{xn} = 0.913512 + 0.621565 p^{xt}$
 (3.59) (6.09)
- $R^2 = .976$ $SE = .043$ $DW = 1.86$ $\rho = .85$

Foreign Trade

- (5) $\log Z = 1.23722 + 0.240053 \log AR + 0.854396 \log \frac{q}{p^n}$
 (4.09) (1.69) (2.37)
- $-0.696806 \log \frac{p^{zt}}{p^n} + 0.102660 D34$
 (-4.90) (1.36)
- where $AR \equiv p^{xt} X + VXS + NF + CF$
- $R^2 = .987$ $SE = .087$ $DW = 1.75$
- (6) $\log (p^{xt} X) = -22.7682 + 6.59086 \log Y^* + 0.759935 \log \frac{p^{xt}}{p^n}$
 (-17.72) (13.09) (3.65)
- $-0.107626 D34 - 1.33928 \log Y$
 (-2.20) (-4.81)
- $R^2 = .997$ $SE = .056$ $DW = 2.06$
- (7) $BP = p^{xt} X - p^{zt} Z + VXS - VZS + NF + CF$

The Monetary Sector

(8) $R = R_{-1} + BP$

(9) $\log M = 0.524731 + 0.372252 \log (H + R) + 0.637342 \log M_{-1}$
 (3.05) (2.22) (3.90)

$R^2 = .997$ $SE = .054$ $DW = 1.33$

(10) $\log CR = 0.895840 + 1.06948 \log M - 0.10492 D17$
 (15.97) (40.92) (-1.92)

$R^2 = .996$ $SE = .065$ $DW = 2.29$

The Domestic Sector

(11) $\log Y = 1.29690 + 0.156617 \log \frac{CR}{P} + 0.302928 \log (Z + ZS) - 0.0378884 D37$
 (5.53) (2.06) (4.64) (-2.24)
 + $0.414799 \log Y_{-1}$
 (3.36)

$R^2 = .999$ $SE = 0.022$ $DW = 1.83$

(12) $y = PY$

(13) $P = aP^n + bPZ^n + cPX^n$ $a + b + c = 1$

(14) $\log q = -1.60902 + 0.693972 \log P + 0.381695 \log Y + 0.809324 D37$
 (-6.64) (2.88) (7.24) (2.80)
 + $0.418363 \log q_{-1}$
 (3.37)

$R^2 = .999+$ $SE = .020$ $DW = 1.54$

(15) $\log P^n = 0.122818 + 0.439044 \log q - 0.16466 \log PR + 0.302055 \log P_{-1}^n$
 (3.18) (4.16) (-1.77) (1.86)

$R^2 = .993$ $SE = .034$ $DW = 2.00$

The numbers in the parentheses are the t ratios. The logarithms are to the base e.

APPENDIX II

Definitions of the Variables in the Japanese Model

p^{zt}	Domestic Price of Import Goods
p^{xt}	Domestic Price of Export Goods
p^{zn}	Deflator for Primary Industry Output (Agriculture, Forestry, Fishery, and Mining and Quarrying)
p^{xn}	Deflator for Manufacturing Industry
p^n	Deflator for Service Industry Output (Wholesale and Retail, Transportation and Communication, Construction, Services, Governments, and Others)
p^z^*	Unit Value of Import Goods in the World Market, U.S. Dollar
p^x^*	Unit Value of Export Goods in the World Market, U.S. Dollar
e	The Value of One U.S. Dollar in Japanese Yen, Period Average
Z	Import of Goods, Constant Price
X	Export of Goods, Constant Price
VXS	Export of Services, Current Price
VZS	Import of Services, Current Price
ZS	Import of Services, Constant Price
NF	Net Unilateral Transfers
CF	Net Capital Inflows exclusive of Official Transactions
q	Annual Wage Rate, Million Yen
Y	Gross Domestic Product, Constant Price
y	Gross Domestic Product, Current Price
P	Deflator for Gross Domestic Product
Y^*	Index of Real GDP's of Developed (excluding Japan) and Developing Market Economies, weighted by Japanese Trade
BP	The Balance of Payments on Official Settlement Basis
R	International Reserves, End of Period

M Money Supply (M1), End of Period
H Domestic Reserves, End of Period
CR Domestic Credit, End of Period
PR Productivity of Labor Index
D34 Dummy, 1973 - 74
D17 Dummy, 1971 - 77
D37 Dummy, 1973 - 77

All money variables, unless otherwise noted, are in thousand billion Japanese Yen. Price indexes are in the unit of one with the base year of 1970.

Data Sources

OECD, Main Economic Indicators and National Accounts of OECD Countries; UN, Yearbook of National Accounts Statistics, Yearbook of International Trade Statistics, and Statistical Yearbook for Asia and the Pacific; IMF, International Financial Statistics, and Wharton Econometric Forecasting Associates, Inc.

REFERENCES

- Ackley, G. and H. Ishi. "Fiscal, Monetary, and Related Policies," in H. Patrick and H. Rosovsky, eds., Asia's New Giant: How the Japanese Economy Works, Washington, D.C.: The Brookings Institution, 1976.
- Aukrust, Odd. "PRIM I: A Model of the Price and Income Distribution Mechanism of an Open Economy," Review of Income and Wealth, March 1970.
- Baba, Koichi and Others. "Economic Model for Short-Term Prediction SP-18," Economic Planning Agency, Economic Research Institute, Discussion Paper No. 19, Tokyo, March 1978.
- The Bank of Japan. "The Bank of Japan Econometric Model," Statistics Department, Preliminary Note, August 1972.
- Branson, W.H. "Monetarist and Keynesian Models of the Transmission of Inflation," American Economic Review, Papers and Proceedings, May 1975.
- Branson, W.H. and Johan Myhrman. "Inflation in Open Economies: Supply-Determined versus Demand-Determined Models," in H. Frisch, ed., Inflation in Small Countries, Berlin and New York: Springer-Verlag, 1976.
- Brunner, Karl and Allan Meltzer. "The Explanation of Inflation: Some International Evidence," American Economic Review, Papers and Proceedings, February 1977.
- Bruno, M. "The Two-Sector Open Economy and the Real Exchange Rate," American Economic Review, September 1976.
- Choi, J. "International Trade and Transmission of Inflation in a General Equilibrium Framework," Ph.D. Dissertation, New York University, 1980.
- Choi, J. "International Price Linkage under Fixed and Flexible Exchange Rates," mimeographed, 1981.
- Crockett, A.D. and M. Goldstein. "Inflation under Fixed and Flexible Exchange Rates," International Monetary Fund Staff Papers, November 1976.
- Darby, Michael R. "The NBER International Transmission Model: The Mark II Disequilibrium Version, Estimates and Lessons," University of California at Los Angeles Discussion Paper No. 137, December 1978.
- Dornbusch, Rudiger. "Real and Monetary Aspects of the Effect of Exchange Rate Changes," in R.Z. Aliber, ed., National Monetary Policies and the International Financial System, Chicago and London: University of Chicago Press, 1974.
- Edgren, G., Faxen, K.O. and C.E. Odhner. "Wages, Growth and Distribution of Income," Swedish Journal of Economics, September 1969

- Hamada, K. and S. Makoto. "International Transmission of Stagflation under Fixed and Flexible Exchange Rates," Journal of Political Economy, October 1978.
- Hernandez-Cata, E. "The Japanese Sector of the Multi-Country Model," Board of Governors of the Federal Reserve System, International Finance Discussion Papers, Number 131, February 1979.
- Houthakker, H.S. and S.P. Magee. "Income and Price Elasticities in World Trade," Review of Economics and Statistics, 51, May 1969.
- Johnson, Harry G. "Inflation: A Monetarist View," in H.G. Johnson, Further Essays in Monetary Economics, Cambridge, Massachusetts: Harvard University Press, 1973.
- Jones, R.W. and Corden, W.M. "Devaluation, Non-Flexible Prices, and the Trade Balance for a Small Country," Canadian Journal of Economics, February 1976.
- Katseli-Papaefstratiou, L.T. "Transmission of External Price Disturbances and the Composition of Trade," Journal of International Economics, 10, August 1980.
- Katz, Samuel I. "Imported Inflation and the Balance of Payments," New York University Graduate School of Business Administration, The Bulletin, Nos. 91-92, October 1973.
- Krause, L.B. and W.S. Salant, eds. Worldwide Inflation, Washington, D.C.: The Brookings Institution, 1977.
- Kravis, Irving B. and Robert Lipsey. "Price Behavior in the Light of Balance of Payments Theories," Journal of International Economics, (8), 1978.
- Laidler, D.E.W. "An Elementary Monetarist Model of Simultaneous Fluctuations in Prices and Outputs," in H. Frisch, ed., Inflation in Small Countries, Berlin and New York: Springer-Verlag, 1976.
- Machlup, Fritz. "How Inflation is Transmitted and Imported," Euromoney, September 1975.
- Miller, M.H. "Can a Rise in Import Prices be Inflationary and Deflationary? Economists and U.K. Inflation 1973-74," American Economic Review: September 1976.
- Organization for Economic Cooperation and Development. "The International Transmission of Inflation," OECD Economic Outlook, Special Section, July 1973.
- Parkin, M. "A 'Monetarist' Analysis of the Generation and Transmission of World Inflation, 1958-71," American Economic Review, Papers and Proceedings, February 1977.

- Prachowny, M.F. "The Effectiveness of Stabilization Policy in a Small Open Economy," Weltwirtschaftliches Archiv, 109(2), 1973.
- Shinkai, Y. "A Model of Imported Inflation," Journal of Political Economy. July-August 1973.
- Turnovsky, S. "The Relative Stability of Alternative Exchange Rate Systems in the Presence of Random Disturbances," Journal of Money, Credit and Banking, February 1976.
- Turnovsky, S.J. and Andre Kaspura. "An Analysis of Imported Inflation in a Short-Run Macroeconomic Model," Canadian Journal of Economics, Vol. 7, August 1974.