International Finance Discussion Papers

Number 128

January 1979

IMPACT OF THE DOLLAR DEPRECIATION OF THE U.S. PRICE LEVEL: AN ANALYTICAL SURVEY OF EMPIRICAL ESTIMATES

by

Peter Hooper and Barbara Lowrey

CONTENTS

Tables/Charts

Peter Hooper and
Barbara Lowrey */

Impact of The Dollar Depreciation on the U.S. Price Level: An Analytical Survey of Empirical Estimates

Introduction

The decline in the foreign currency value of the dollar over the past year and a half and the increase in U.S. price inflation more recently have raised questions concerning the extent to which the dollar depreciation has raised U.S. prices. A number of estimates of the impact of exchange rate changes on U.S. domestic prices have been made by the staff of the Federal Reserve Board, and by others. The purpose of this paper is to survey and analyze a number of alternative estimates that have been made.

Estimates of the impact of a 10 per cent depreciation of the dollar on the increase in the level of consumer prices, for example, range from 0.8 per cent to 4.0 per cent. This range of estimates reflects differences in: (a) analytical approaches (b) underlying assumptions about the behavior of oil prices, domestic policies and other factors and (c) alternative measures of average exchange rate changes.

---

*/ The views expressed herein are the authors' and do not necessarily represent the views of the Board of Governors of the Federal Reserve System or anyone else on its staff. We are indebted to Richard Berner, Jeffrey R. Shafer, and Stephen Thurman for their considerable help at the various stages of work that went into this paper. Valuable comments on an earlier draft were also provided by Ernesto Hernández-Catá, Peter Isard, Sung Kwack, other members of the International Finance Division as well as members of the Wages, Prices and Productivity Section at the Federal Reserve Board and by Steven W. Kohlhagen and Neil Pinsky. Any errors that remain are, of course, the authors'.

Two basic analytical approaches can be identified. The first is partial-equilibrium analysis, which treats the exchange rate as determined exogenously and considers the direct and indirect effects of a given exchange rate change on domestic prices. The second approach is general-equilibrium analysis, which treats the exchange rate as determined endogenously and allows for consideration of both the independent price effects of factors that caused the exchange rate change and feedbacks from changes in domestic prices and other variables to the exchange rate itself.

Most of the empirical estimates surveyed adopt partial-equilibrium approaches in varying degrees of structural detail. These range from single equation estimates in which all domestic price determinants (including the exchange rate or import prices) are treated exogenously, to full structural models which take into account wage-price relationships, exchange-rate-induced changes in aggregate demand and the influences of alternative macroeconomic policy assumptions. Under the general-equilibrium approach, the role of the exchange rate as a causal factor becomes less clear. With exchange rate changes induced by changes in other variables that also affect prices, price changes should be viewed as "associated with" rather than directly "caused by" exchange rate changes.

The alternative theoretical approaches to analyzing the price effects of exchange rate changes are considered in greater detail in Section I. The various channels through which exchange

rate changes relate to domestic prices are outlined, including descriptions of how these relationships can be affected by alternative policy assumptions as well as by partial-equilibrium and general-equilibrium considerations.

Section II describes a procedure for "standardizing" the estimates of models that use different weighted indexes of the average foreign currency value of the dollar. Also, since many of the empirical estimates surveyed relate domestic prices to import prices rather than directly to exchange rates, in this section we derive an empirical relationship between import prices and the standard exchange rate index we have selected (the Federal Reserve Board's multilateral-trade-weighted index). This analysis focuses on nonoil import prices, with oil prices considered separately.

The next two sections describe specific partial-equilibrium and general-equilibrium estimates of the impact of exchange rate changes on domestic prices. For the sake of convenience and comparability we limit these descriptions to estimated impacts on U.S. consumer prices (or the closest available substitute). Where alternative exchange rate measures have been used, the estimates are converted to a consistent basis using the technique outlined in Section II.

It should be noted at the outset that many of the estimates and models included in this survey were developed for purposes other than the analysis of the price effects of exchange rate changes. In order to present estimates on a comparable basis, in some cases we have had to modify results, and in other cases we have

abstracted substantially from the original purpose of the model. It would be inappropriate, therefore, to pass judgment on any of the estimates included beyond the narrow focus of this paper.

I. Framework of Analysis

This section outlines the several approaches that have been employed to estimate the impact of exchange rate changes on the domestic price level.

A. Exogenous Exchange Rate Analysis

Single Equation Approach

The single equation approach to price determination is illustrated in Chart 1. The domestic price level is expressed as a function of labor costs, domestic material costs (commodity prices), demand pressure (capacity utilization) and import prices (or, in some cases, exchange rate-adjusted foreign prices). In this model, the exchange rate typically affects the domestic price level through its impact on import prices.[1/] Other variables are treated exogenously -- demand pressure, labor costs and foreign prices, for example, are assumed to be unaffected by exchange rates.[2/]

The coefficient on import prices in a domestic (consumer) price equation implicitly captures the influence of import prices through several different channels. These channels include (1) direct changes in prices of final goods that are imported, (2) pressure on prices of domestically produced final products that compete with

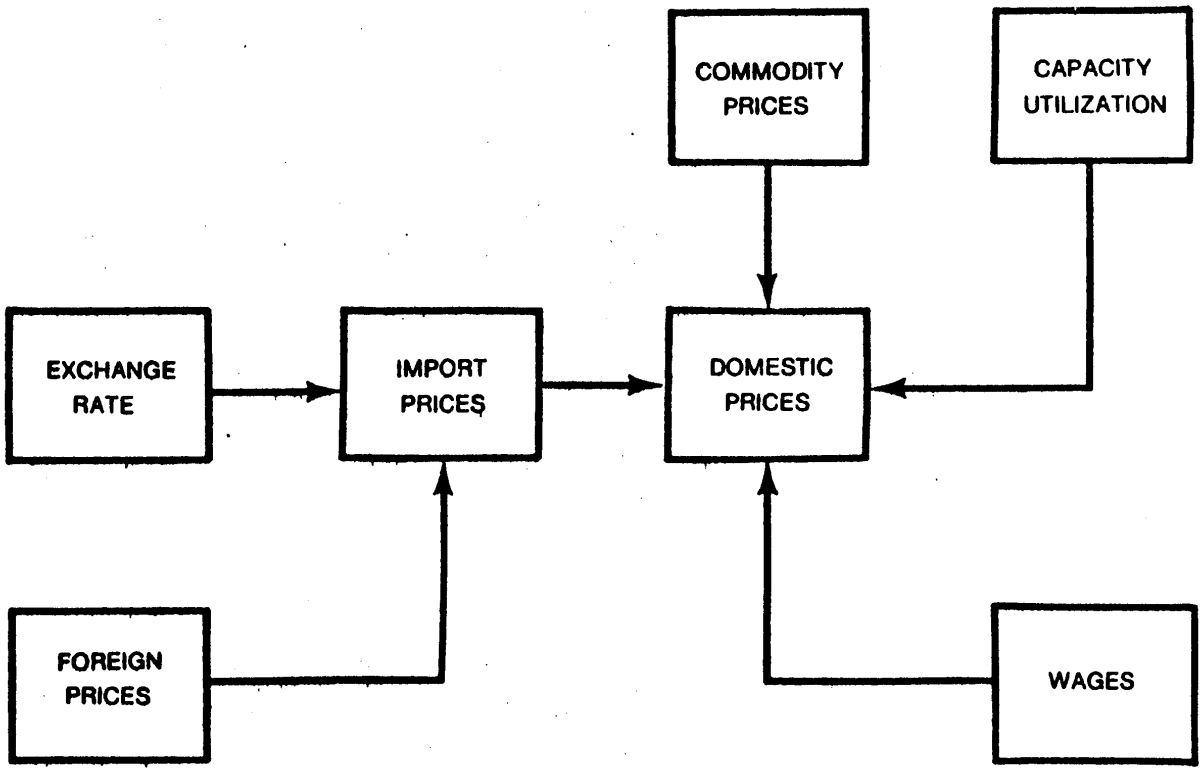
---

1/ These effects are considered in detail in Section III below.

2/ In several of the "single equation" estimates surveyed below, the price equation is in fact the reduced form of a theoretical model in which wages are specified endogenously. However, it is not clear that reduced-form estimation will yield empirical results that are consistent with a model in which a structural wage equation is estimated. (See Dhrymes (1970) pp. 227-229.

Chart 1

Exogenous Exchange Rate Impact, Single Equation Approach



imports, and (3) changes in the costs of producing domestic products that use imported materials and component parts (as well as their domestic substitutes) as inputs.

Structural Model Approach

A more complete structural model of domestic price determination takes into account the endogeneity of each of the price determinants shown in Chart 1. This is illustrated in Chart 2, where the solid boxes correspond to those in Chart 1.[1/]

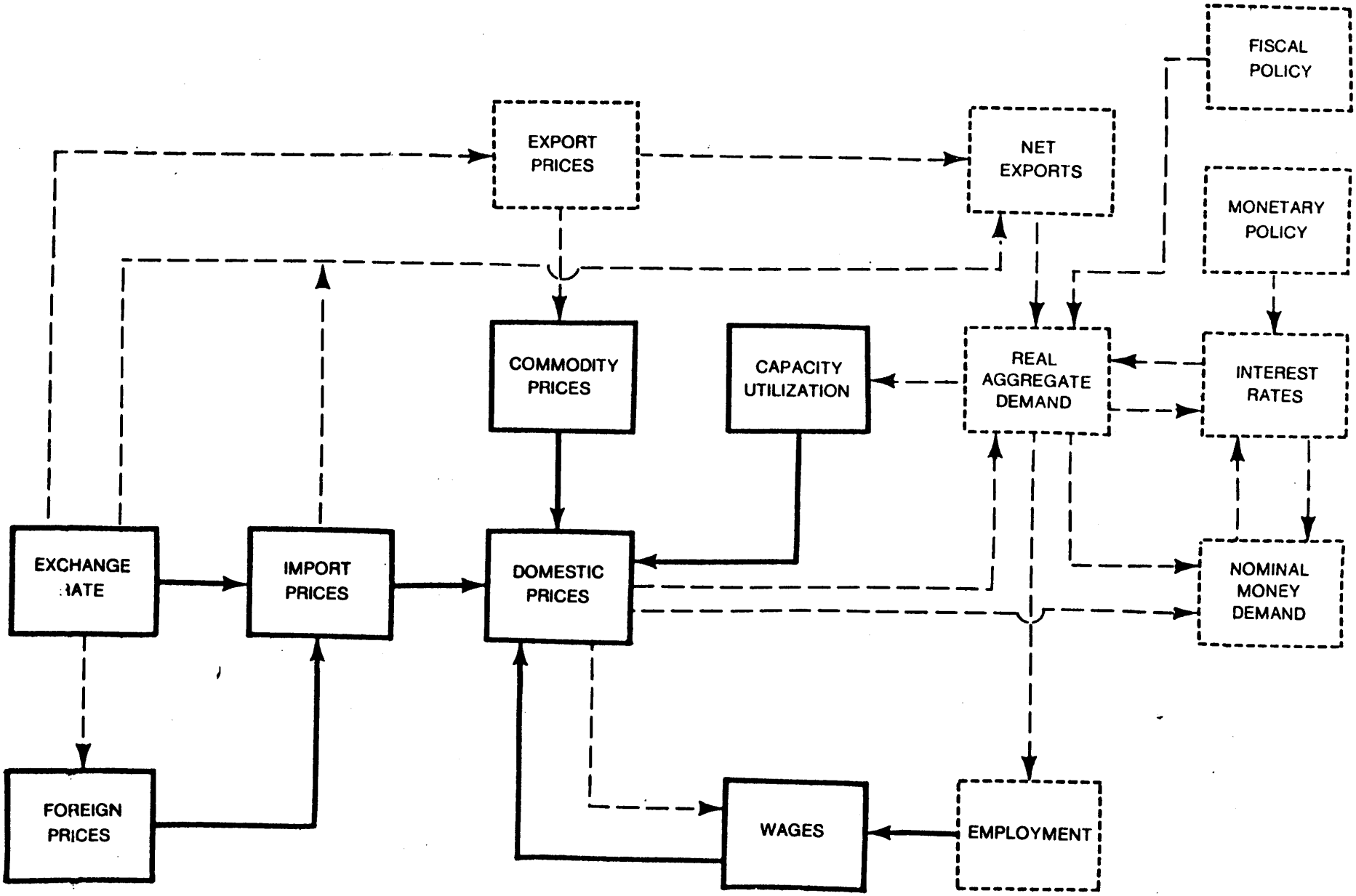
To begin with, a depreciation of the dollar will induce relative price changes that work to shift demand away from foreign goods towards domestic goods. That is, as the dollar prices of U.S. imports rise, U.S. consumers shift from imported goods to domestic substitutes, and as the foreign currency prices of U.S. exportables fall, foreign consumers shift from foreign goods to U.S. exports. These demand shifts affect domestic prices through several channels (in addition to those outlined above for the single equation model). The domestic prices of U.S. commodities that are sold in competitive world markets (wheat and soybeans, etc.) rise quickly. Other domestic prices rise more slowly as the rise in real net exports increases domestic aggregate demand, putting upward pressure on domestic capacity utilization and demand for labor (hence, employment and labor costs).[2/]

1/ Chart 2 should not be interpreted as a complete structural model; the chart is meant only to illustrate the relationships essential to the exercise at hand. A number of lesser determinants and feedback relationships are not illustrated. Also, we have abstracted from the important role of price expectations in both wage and price determination.

2/ These aggregate demand effects could be offset or reversed if domestic economic policies were not accommodating, as discussed below.

Chart 2

Exogenous Exchange Rate Impact, Structural Model Approach



Second, labor costs (wages) are influenced by consumer prices on the labor supply side as workers seek to maintain real wages. The initial rise in prices following an exchange rate depreciation will be augmented as these wage-price dynamics are worked through.

Third, a depreciation of the dollar also affects foreign prices. When the dollar declines in value, foreign currencies rise in value and the pattern of adjustments described above operates in the opposite direction on foreign prices. The downward pressure on foreign prices tends over time to moderate the rise in U.S. import prices and domestic prices.

Policy Considerations

The full price impact of a dollar depreciation depends importantly upon the responses of monetary and fiscal policy authorities.

As illustrated in Chart 2, upward pressure on domestic prices and real GNP, described above, raises demand for nominal money balances. If the money supply is held constant by the Federal Reserve, interest rates will rise to choke off the increased money demand.[1/] The rise in interest rates also will depress real

1/ For convenience we focus on the stock rather than the flow of money in this discussion, because we are analyzing the impact of a one-time dollar depreciation on the price level, not on the inflation rate. The arguments presented here also can be made in terms of rates of change, although a one-time depreciation would have only a transitory impact on the inflation rate, and the associated accommodating monetary policy would involve only a transitory increase in the rate of money growth.

aggregate demand and reduce the initial inflationary impact of the depreciation. On the other hand, if interest rates are pegged by the Federal Reserve, aggregate demand will rise, allowing the maximum domestic inflationary effects of the depreciation to work through.

The inflationary impact would be somewhere between the two extremes outlined above if monetary and fiscal authorities combined efforts to pursue a fixed real growth target. In this case both interest rates and money supply would rise somewhat. The rise in interest rates would depress domestic absorption by enough to offset the depreciation-induced rise in real net exports, leaving real GNP unchanged.[1/]

The relationship between the dollar depreciation and foreign price changes will be affected similarly by the stance of economic policy abroad.

B. Endogenous Exchange Rate Analysis

When the analysis takes into account the endogenous determination of the exchange rate, the increase in domestic prices associated with a depreciation can vary in two respects. First, alternative factors that cause exchange rate changes can affect domestic prices independently of their impact through the exchange rate; these independent effects can vary greatly. Second, both the exchange rate change and the factors that caused it initiate changes in other variables that feedback to the exchange rate itself, thereby altering the longer-run price effects of the original depreciation.

1/ This can be viewed as a net decline in domestic consumer welfare resulting from a deterioration of the U.S. terms of trade.

An example of the importance of other variables causing a depreciation is illustrated in Chart 3. Here we have assumed that the depreciation is brought on by a change in foreign monetary policy. A foreign monetary contraction (ceteris paribus) will raise foreign interest rates and reduce foreign real aggregate demand. The increase in foreign interest rates will shift asset demands from dollar-denominated assets to foreign currency-denominated assets, and the reduction in foreign aggregate demand will reduce foreign imports and the U.S. trade balance. Both of these shifts will cause the dollar to depreciate and U.S. import prices (in dollars) and domestic prices to rise as outlined in Chart 2. At the same time, however, the reduction in foreign aggregate demand will depress foreign prices as well as U.S. net exports.[1/] The reduction in foreign prices from what they otherwise would have been reduces U.S. import prices and at least partly offsets the domestic price effect of the depreciation. The reduction in U.S. net exports also has offsetting deflationary effects through its impact on domestic aggregate demand. In this case the price increase associated with the depreciation would be smaller than an exogenous exchange rate analysis would have suggested.

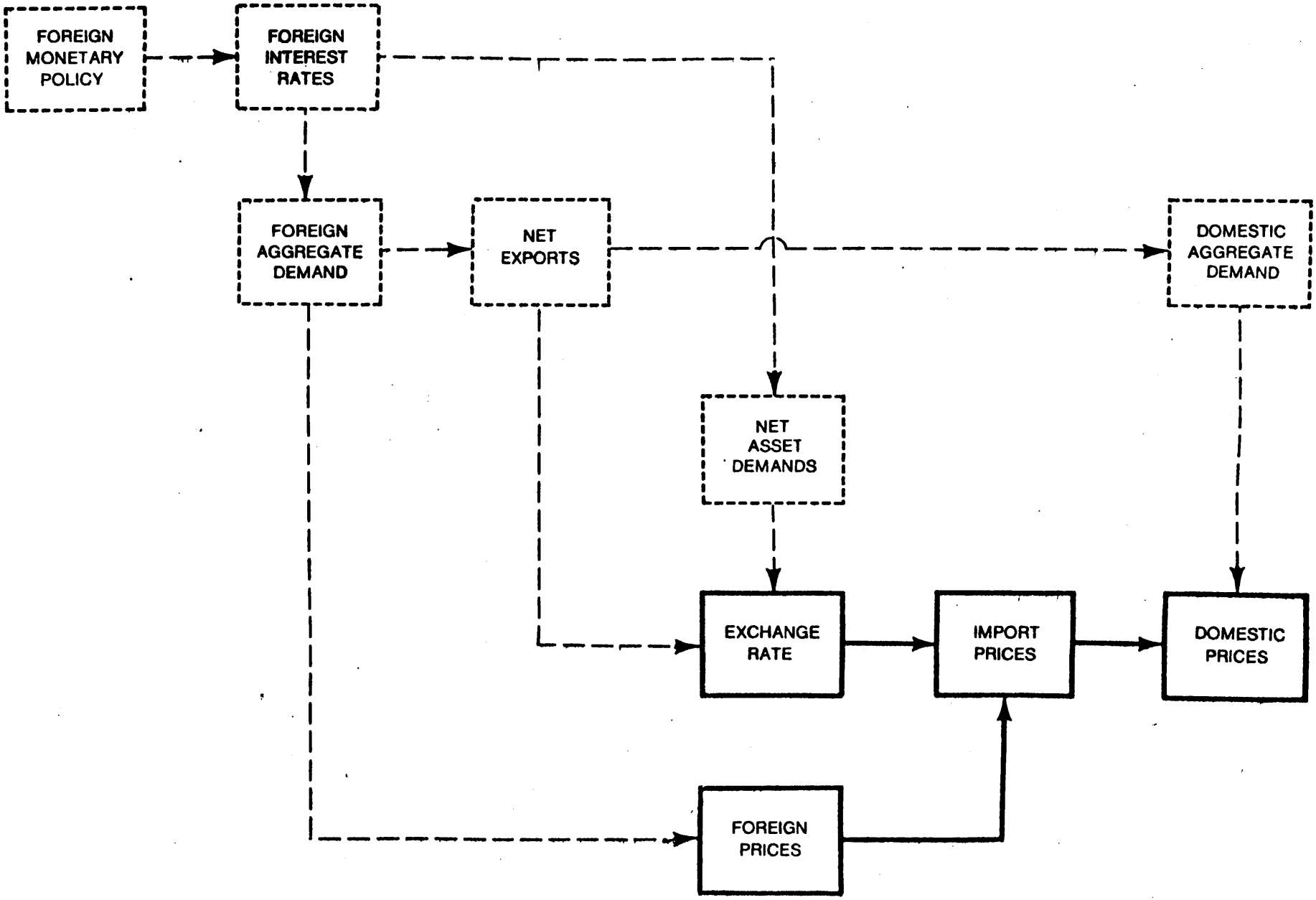
Similarly, if the depreciation were induced by a domestic monetary expansion, the increase in domestic prices associated with the depreciation would be greater than that suggested by exogenous analysis to the extent that the monetary expansion raised domestic

---

1/ A monetarist interpretation might suggest more direct causal links between foreign monetary policy and foreign prices and asset demands. This interpretation, however, does not affect the essential point of the argument presented here, that the decline in foreign prices will offset at least part of the impact of the exchange rate depreciation on import prices and domestic prices.

Chart 3

Endogenous Exchange Rate Impacts, Simplified Example Based on Change in Foreign Monetary Policy



prices independently of its impact through the exchange rate. Clearly, it becomes difficult to view the exchange rate as a causal factor in domestic price determination in the case of monetary shocks.

Exogenous exchange rate analysis will approximate the price effects of exchange rate changes more closely, however, when the exchange rate changes in response to shocks that have little independent impact on domestic prices. An exogenous shift in foreign asset preferences away from dollar denominated assets, for example, would cause the dollar to depreciate without greatly affecting foreign or domestic prices through channels other than the exchange rate.[1/]

The second aspect of the endogenous determination of exchange rates -- feedbacks from changes in interest rates, aggregate demand and prices -- will influence the initial inflationary impact of an exchange rate change in two directions. Perhaps the most important feedback is from domestic and foreign interest rates. The rise in domestic interest rates and decline in foreign interest rates associated with a depreciation of the dollar (assuming authorities do not peg interest rates) will shift asset demands toward dollar-denominated assets, thus putting upward pressure on the dollar and moderating the initial depreciation. Feedbacks from prices and aggregate demand will work in the opposite direction to augment the initial depreciation by reducing the trade balance,[2/] although these effects may take

1/ As in the exogenous exchange rate case, the stance of monetary and fiscal policy during the period of adjustment to the "shock" still has an important influence on the full price effects associated with the exchange rate change.

2/ Imports will rise with the increase in aggregate demand, and the initial shift from foreign goods to domestic goods will be moderated as domestic prices rise.

place with longer lags and may be smaller in magnitude than the asset market effects. Under conditions of rational expectations in the foreign exchange markets, such feedbacks would be reflected immediately in the exchange rate as they would be discounted by market participants.

II. Alternative Measures of Exchange Rate Changes and Their Impacts on Import Prices

Many of the models surveyed relate domestic prices to import prices rather than directly to the exchange rate. Moreover, among those models that do include exchange rates, different exchange rate indexes are employed, and a given percentage change in one index can imply a different inflationary impact than the same percentage change in another index. In order to provide a basis for comparing the estimates of the various models, we have attempted to "standardize" these estimates by translating them in terms of the impact of a change in a "standard" exchange rate index. For models that include only import prices, a change in the standard exchange rate index is translated into a change in import prices. The Federal Reserve Board's multilateral-trade-share-weighted index of the dollar's average value against the currencies of ten major industrial countries was chosen as the standard exchange rate index.[1/]

Several of the models surveyed have used bilateral-trade-share-weighted indexes (using weights reflecting shares in U.S. trade). For purposes of translating the estimates of these models into impacts on a multilateral exchange rate index basis, a nonoil import price equation was estimated, using alternatively, the multilateral-trade-weighted index and a bilateral-trade-weighted index of the same currencies. Oil import prices, which are considered separately below, were not included in the import price equations because (a) oil prices are set in dollars so that they do not immediately reflect changes in the dollar's exchange rate, (b) the discontinuity of

OPEC pricing behavior has not lent itself to satisfactory econometric modeling,

1/ The weights employed are each country's share of the 1972-76 total world trade of the ten countries included (Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland and the United Kingdom). This particular index and exchange rate indexing in general are described in Hooper and Morton (1978).

and (c) several of the models considered were estimated over earlier periods when oil accounted for a much smaller share of total imports. The following two equations were estimated over the period 1960Q1 to 1978Q2 using quarterly data:[1/]

$$(1)\quad PM = \underset{(5.9)}{-3.2} - \underset{(5.9)}{.57ER_m} + \underset{(10.4)}{1.0\,PF_m} + \underset{(2.9)}{.5\,CUF_m} + \underset{(4.0)}{.1\,PCS} \qquad \bar{R}^2 = .998,\ DW = 1.96$$

$$(2)\quad PM = \underset{(7.0)}{-4.7} - \underset{(5.9)}{.88\,ER_b} + \underset{(10.7)}{1.0\,PF} + \underset{(1.9)}{.4\,CUF_b} + \underset{(4.2)}{.1\,PCS} \qquad \bar{R}^2 = .998,\ DW = 2.1$$

where PM = Unit value of U.S. nonoil imports

ER = Exchange rate index (in terms of foreign currency units per dollar), with a 2-quarter distributed lag. [2/]

PF = Weighted average of foreign consumer prices with a 2-quarter distributed lag. [3/]

CUF = Weighted average of foreign capacity utilization (GNP gap).

PCS = World prices of coffee and sugar.

Subscript "m" denotes multilateral-trade-weighted index

"b" denotes bilateral trade weighted index

numbers in parentheses are t-ratios.

The variables were expressed in log terms so that the coefficient estimates are elasticities. The difference in elasticities on the exchange rate variables between the two equations reflects differences in historical movements between the two exchange rate indexes. As illustrated in Chart 4, over the past five years the index using bilateral trade weights has been less volatile than that using multialteral weights.[4/] This is because the Canadian dollar, which has a much greater weight in the bilateral index, has[5/]

1/ The theoretical basis for these price equations and the data sources are described in Hooper (1976). A specification allowing for differential impacts between exchange rate depreciations and appreciations ("ratchet effects") was also tested; no conclusive results were obtained, and further work in this area is clearly in order. Results similar to those shown in equations (1) and (2) were obtained for the sub-sample periods 1970Q1 to 1978Q2 and 1973Q1 to 1978Q2.

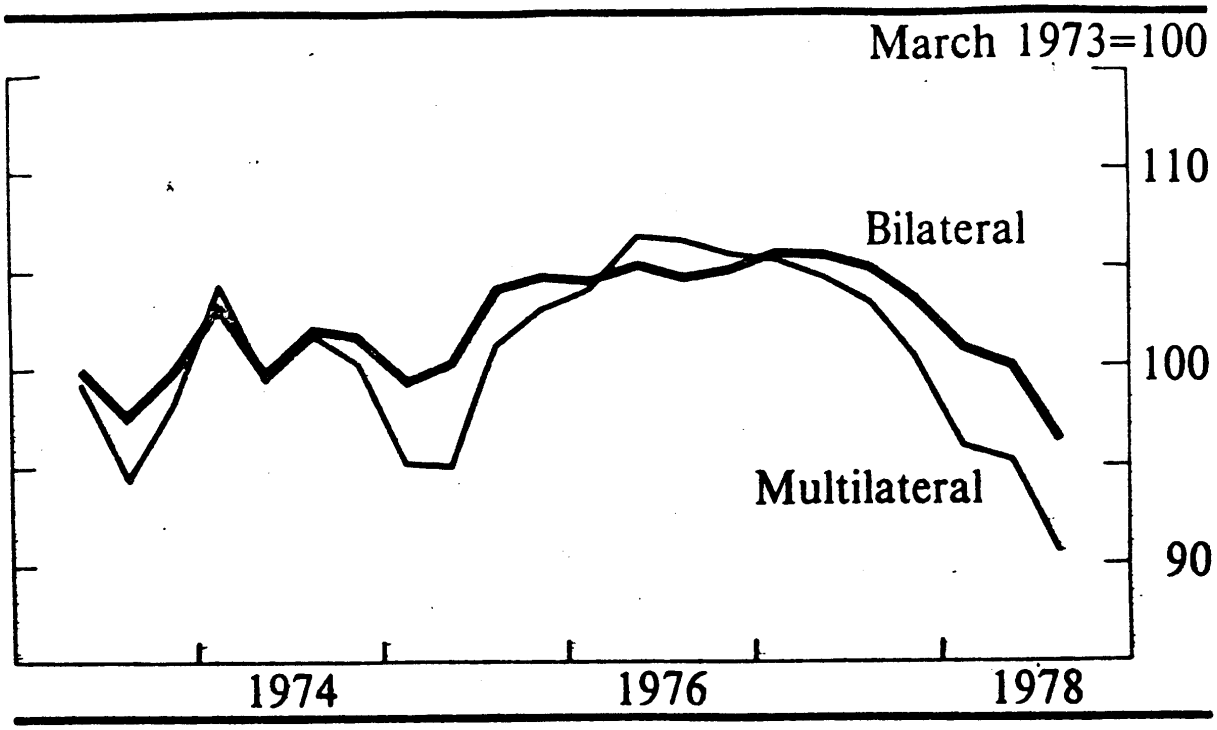
2/ Longer distributed lags were tested, but impacts beyond two quarters were generally small and the overall equation fit was reduced.

3/ Foreign unit labor costs and wholesale prices were also tested and yielded similar results.

4/ This difference was much smaller for other indexed foreign variables in the equation.

5/ See Hooper and Morton (page 785).

Indexes of average exchange value of U.S. dollar, alternative weighting schemes



been relatively stable or has actually declined against the U.S. dollar, contrary to most other currencies included in the index.

For a given pattern of import price movements, the exchange rate index with the higher variance can be expected to yield a lower elasticity in our estimated equation. This offsetting relationship between variance and elasticities insures a rough consistency between predictions of the price effects of a given set of bilateral exchange rate changes based on historical movements of the two exchange rate indexes. To take an example, for the third-quarter 1976 to the third quarter 1978, the dollar depreciated by about 14 per cent on multilateral-trade-weighted average basis against ten major currencies and by 9 per

cent on a bilateral-trade-weighted average basis.[1/] According to equation (1) the dollar depreciation during this period led to a .57 x 14 per cent = 8.0 per cent increase in nonoil import prices, compared with a .88 x 9 per cent = 7.9 per cent increase according to equation (2).[2/] The results of this standardization technique should be viewed as no more than rough approximations of what each of the models would suggest on a common basis, since the bilateral trade weights we have selected may not correspond exactly to those used in other studies. A more consistent standardization procedure than the one we have outlined in this section would have been to reestimate each of the models surveyed using a common exchange rate index. This procedure, however, was infeasible.

The results of equation (1) are also used to translate exchange rate changes into import prices for those models that include only import prices. If oil import prices rise by the same proportion as nonoil prices in response to a 10 per cent depreciation on a multilateral-weighted-average basis, total import prices will rise by 5.7 per cent.[3/]

1/ It should be noted that the relationship between bilateral and multilateral index movements represents an historical average. While it held for the most recent depreciation, it will not necessarily hold at every point in time.

2/ These estimates may be slightly understated to the extent that the effects of depreciation-induced changes in coffee and sugar prices (which are included separately in the equations above) are not captured in the exchange rate coefficient. This bias is likely to be small, however, given (1) the relatively small share of coffee and sugar in the total nonoil imports, (2) the importance of U.S. consumption in the world markets for these commodities, and (3) some degree of price elasticity in U.S. demand.

3/ Any assumption concerning OPEC's pricing response to a dollar depreciais necessarily arbitrary. We might have assumed, more explicitly, that oil prices in the long run are set in terms of an SDR currency basket (a proposal that reportedly has been considered by OPEC). In this case a 10 per cent dollar depreciation would raise the dollar price of oil by 6.7 per cent, which is not far out of line with the assumption we have adopted.

However, if oil prices are not affected by the depreciation, total import prices will rise by 3/4 as much, or 4.3 per cent, since nonoil imports accounted for roughly 3/4 of the value of merchandise imports in 1977-78. Finally, for models that include services with import prices, we implicitly assume that the impact of a depreciation on the service import deflator is the same as that on the total goods import price index.

III. Empirical Estimates Based on Exogenous Exchange Rate Analysis[1/]

A. Single Equation Estimates

We have surveyed several single-equation estimates of domestic price determination. In some cases, the estimated equations are partial reduced forms of theoretical models in which wages are specified endogenously. That is, the wage variable is replaced by its determinants (which are in fact endogenous variables themselves). None of the single equation estimates considered relate domestic prices directly to exchange rates, rather, each focuses on the linkeage between import prices and domestic prices. These results are translated into exchange rate effects using the relationships between exchange rates and import prices described in Section II. All of the single equation estimates employ some form of lag structure or dynamic adjustment of domestic inflation to changes in its determinants, so that some of the longer-run structural effects of exchange rate changes (wage-price dynamics, etc.) may be captured indirectly in the lag structure.

1/ This is not an exhaustive survey, as our intention is only to provide representative samples of alternative approaches. We have not included a representative of the strict monetarist approach to price determination. The only such model specifically addressing international influences on domestic inflation that has come to our attention is a study by Levy (1977). However this study did not treat the exchange rate as an easily identifiable variable. The predictions of several large econometric models not covered in this paper were considered in a survey paper by Deardorf and Stern (1977), although that paper was limited to an analysis of countries other than the United States.

1. A consumer price equation maintained by the Wages, Prices, and Productivity (WPP) Section at the Federal Reserve Board relates changes in the U.S. Consumer Price Index (CPI) to changes in wages, labor productivity, the GNP gap, and total import prices, all of which are treated exogenously. The equation was estimated using quarterly data for the period 1960-1978; the variables are expressed as quarterly changes. Import prices are included with a polynominal distributed lag. The estimated elasticity of domestic consumer prices with respect to import prices within 4 quarters is 0.2.[1/] This translates into a 0.8 per cent consumer price increase within one year for every 10 per cent depreciation of the dollar, if oil prices are unaffected, and a 1.1 per cent price increase if oil imports rise by the same proportion as nonoil import prices. These should be considered as short-run impacts in view of the short lags and the exclusion of wage-price feedbacks.

2. Spitäller (1978) has estimated empirically for various industrial countries the reduced form of a model of inflation in which wages are treated endogenously. The consumer price inflation rate is estimated as a function of changes in the domestic money stock, the output gap (which was measured in a variety of ways in different experiments), changes in import prices, and a lagged dependent variable. The data covered 1958 - 1976 and were measured as four-quarter percentage changes. The estimated "steady-state" elasticity of domestic prices with respect to import prices (taking into account the coefficient on the lagged-dependent variable) was .27. Using our transformation, this

---

[1/] McNown (1975) has obtained essentially the same results using a similar model with annual data except that he estimated a separate wage equation, and substituted the estimated coefficients of wage determinants into the price equation.

estimate implies a 1.1 per cent increase in comsumer prices for every 10 per cent depreciation of the dollar if oil import prices do not rise, and a 1.5 per cent increase if oil prices increase proportionately to nonoil import prices.

3. Modigliani and Papademos (1975) tested several alternative single equation models explaining changes in the nonfood component of the CPI. The equations included various combinations of the unemployment rate, productivity change, money growth, changes in prices of farm products, changes in prices of nonfood imports and a lagged dependent variable. Labor wages were treated endogenously. The equations were estimated over the period 1953 - 1971, using annual data. Across those equations that included the import price variable, the authors generally obtained import price elasticities of about 0.1 after one year and 0.3 in the long run (steady state). These estimates are equivalent to a 0.4 per cent increase in prices in the short run and a 1.3 per cent increase in the long run following a 10 per cent depreciation with no oil price response.[1/] With an oil price response, the long-run estimate becomes 1.7 per cent.

4. Dornbusch and Krugman (1976) estimated equations similar to those presented by Modigliani and Papademos, using annual data for several countries. The equation explaining U.S. consumer price changes included the unemployment rate, import price changes and a lagged dependent variable. The estimated import price elasticity was .14 after one year and .42 in the long run, implying domestic price increases of 0.6 and 1.7 per cent respectively, following a 10 per cent depreciation with no increase in oil prices. With an

---

[1/] This conversion assumes that food prices respond to exchange rate changes in the same manner as nonfood prices; to the extent that food prices are less sensitive than other prices, the estimates given here are overstated.

upward adjustment in oil prices, domestic prices would rise by 2.3 per cent in the long run. The greater sensitivity of domestic prices wtih respect to exchange rate changes implied by the Dornbusch-Krugman (D-K) estimates relative to the estimates of other single equation studies may have resulted from the exclusion of GNP gap and commodity price variables. That is, the coefficient in D-K's import price variable may be biased upward to the extent that import prices were positively correlated with excluded variables (GNP gap and commodity prices), which would have been associated with domestic prices in a positive direction.

B. Input-Output Models

Several authors have used input-output models in order to trace the effects of higher import and commodity export prices through the various domestic sectors of the economy. This approach involves "accounting" rather than behavioral analysis, but it ensures consistency of impacts across sectors. One useful feature of the input-output approach is the ability to analyze the effect of exchange rate changes on the "commodity" sectors. Prices in such sectors as livestock, agricultural products, metal ores, etc. are determined in competitive world markets, so that prices of the "whole" component of domestic production respond quickly to an exchange rate change. This approach may provide a more complete accounting of the direct price effects at various states of processing, but it excludes many competitive price effects (since substitution elasticities are assumed zero) and wage-price effects.

1. Isard (1974) at the Federal Reserve Board, calculated the effects of a one-time devaluation against all currencies except the Canadian dollar and the Latin American currencies, with the "dollar-linked" area accounting

for 20 per cent of world consumption of primary commodities. Isard did not use regression analysis to make his calculations, but rather used assumptions about price elasticities to estimate the rise in commodity prices (i.e., prices of homogeneous goods, including petroleum) for each percentage point devaluation of the dollar. Given the nature of homogeneous goods, both import and domestic prices would rise by identical amounts. Isard also implicitly assumed that foreign exporters of heterogeneous products denominated their exports in home currencies, and do not change these prices with an exchange rate realignment, so that the dollar price of exports from these countries will rise by the full amount of the devaluation. We have adopted Isard's analytic framework and assumptions to estimate the effects of a 10 per cent depreciation as measured by the FRB multilateral index. For a 10 per cent depreciation, the prices of foodstuffs and non-food primary products are expected to rise by 6 per cent. Since these commodities account for 10 per cent of the CPI, the index would increase by a .6 per cent. The estimated impact of higher prices of finished goods would add another .2 to the index, raising the overall impact to .8 per cent. Isard noted that the effects would occur in the amount of time it takes domestic industries to shift forward the first round of their cost increases -- perhaps 3 to 6 months.

2. Norhaus and Shoven (1974) used a similar approach to analyze the effect of higher import prices on domestic prices between November 1972 and August 1973 -- the time of the commodity price boom. While they attributed a substantial part of the U.S. inflation to external influences through higher import prices, they do not clearly distinguish between the effects of

the dollar depreciation and other factors, such as crop failures or supply shortages, that also caused import prices to rise. The numbers reported by Norhaus and Shoven seem to imply that import prices rise by more than the actual depreciation; however, the exact "pass-through" estimate is not clearly specified. Norhaus and Shoven focussed on the Wholesale Price Index (WPI) and we have calculated the effects on the CPI by multiplying the initial results by the ratio of the CPI change to the WPI change over the period considered (.36). Using our adjustments, we infer that the Norhaus and Shoven approach yields a 0.9 per cent increase in domestic consumer prices for a 10 per cent depreciation of the dollar.[1/]

C. Simplified Structural Models

Several estimates incorporate more than single equation or input-output effects but less than full structural model effects.

1. Prakken (1978) has estimated a model that (1) relates import prices to exchange rates, (2) relates domestic prices to import prices (among other determinants), and (3) includes the estimation of a structural wage equation, so that wage-price effects are taken into account explicitly. Exchange rates, foreign prices and domestic real output are treated exogenously, and policy variables are excluded.

The model, estimated using quarterly data for the period 1956:1 to 1978:1 consists of three behavioral equations and several bridging equations that link changes in consumer prices to changes in the GNP deflator. The first

---

1/ This estimate is much lower than that presented by Nordhaus and Shoven for the WPI. As the authors, point out, the WPI was subject to substantial upward bias due to an inappropriate weighting scheme, which resulted in doublecounting price effects at successive stages of processing.

behavioral equation relates the price of non-fuel imports to weighted-averages of foreign wholesale prices (with a three-quarter lag) and exchange rates (with a seven-quarter lag). The nonfuel import price is combined with the prices of imported fuel and services to obtain a deflator for total imports which is used to determine domestic prices.[1/] A second behavioral equation relates the domestic GNP price deflator to wages, output per manhour, capacity utilization, the import price deflator relative to the GNP deflator in the previous quarter, the change in import prices, and the lagged deflator. This equation reflects several elements: markups over costs, demand pressure as measured by the capacity utilization variable, and competitive constraints as reflected in the import price deflator. The coefficient on the import price variable is .024, with a long run elasticity of .08. The GNP deflator does not caputre the direct effects of higher import prices (since imports are excluded from GNP), and Prakken has estimated a bridging equation to link the GNP deflator with the deflator for personal consumption expenditures. Consumer prices are related to a weighted average of the GNP deflator and the import price deflator, where the weights are estimated to fluctuate as consumers shift between domestic and imported products in response to relative price changes. The final behavioral equation determines wages as a function of the unemployment rate, changes in the unemployment rate, and a seven-quarter distributed lag on consumer prices.

Prakken's results suggest that a 10 per cent depreciation of the dollar, under the implicit assumption of unchanged real GNP growth, will yield a .7

1/ The prices of fuel imports and service payments are treated exogenously and assumed to be unaffected by exchange rate changes. Nonfuel import prices have a weight of .67 in the identity.

per cent increase in the price level after one year and a 1.5 per cent increase in the long run. His estimates for the effects of the dollar's depreciation since 1977 on the U.S. price level are very similar to those obtained using the more detailed MPS model (reported below) under the assumption of a fixed real GNP policy target.

2. Kwack (1977) has estimated the price effects of a dollar depreciation taking into account (1) the single-equation effects of higher import prices, (2) feedback effects from the impact of the exchange rate change on foreign prices and (3) wage-price effects, where the unemployment rate, a determinant of wages, is treated endogenously. Kwack's estimate is based on a model of price linkages across 12 industrial countries. Equations for import prices, domestic consumer prices and the unemployment rate are estimated for each of the countries. In the U.S. case import prices are estimated as a function of foreign consumer prices and exchange rates. Kwack's import price variable includes oil prices although the model was estimated for a period when oil imports accounted for a much smaller proportion of total imports than they do currently. The U.S. consumer prices are expressed as a function of the unemployment rate, domestic output, import prices and a lagged dependent variable. The model was estimated using annual data over the period 1957-73.

The estimated short-run elasticity of U.S. consumer prices with respect to import prices was .2, and the long-run elasticity .33. The estimated elasticity of U.S. total import prices with respect to exchange rate changes (as measured by Kwack's 12-country bilateral-weighted-average index) was 1.2,

suggesting that import prices rise by more than the depreciation. Combining these elasticities, a 10 per cent (bilateral weighted average) depreciation raised the CPI by an estimated 2.4 per cent in the short run, and by 4 per cent in the long run. These estimates are roughly equivalent to 1.8 per cent and 2.7 per cent CPI increases for a 10 per cent multilaterial-weighted average depreciation.

The difference between Kwack's relatively high estimates and others we have reported in this survey can be attributed in large part to the magnitude of his estimated elasticity of total U.S. import prices with respect to exchange rate changes (or "pass-through" coefficient), which was 1.2. This coefficient implies that import prices rise by proportionately more than the exchange rate change whenever the dollar depreciates. This estimate is perhaps on the high side since the prices of many U.S. imports are denominated in dollars (oil, etc.) and are not directly or fully affected by a dollar depreciation. Moreover, it is interesting that Kwack's results across different countries showed domestic prices in other more open economies to be substantially less affected by depreciation of their currencies than in the U.S. case.

D. Full Structural Models

1. Artus and McGuirk (1978) estimated the price effects of a dollar devaluation based on simulations with their recently revised version of the IMF's Multilateral Exchange Rate Model (MERM). The model includes intermediate demand, final demand, supply and price equations as well as bilateral trade equations for each of fifteen industrial countries plus oil exporting countries and the rest of the world. The model has been constructed for purposes of analyzing medium-term adjustment (around 3 years) to exchange rate changes.

It takes into account either explicitly or implicitly all of the partial equilibrium effects outlined in Section I above. A central feature of this model is the incorporation of demand and price linkages across countries, although exchange rates are treated exogenously.

A model simulation was run in which (1) the dollar was devalued by 10 per cent against all currencies, (2) domestic policy authorities were assumed to hold the path of real GNP unchanged, and (3) oil prices (set in dollars) were assumed unaffected by the dollar devaluation. In this simulation total U.S. import prices rose by 8.1 per cent, export prices by 4.3 per cent and consumer prices by 3.5 per cent in the long run.[1/] The translation of this result into an estimate based on a 10 per cent depreciation in the standard exchange rate index we have selected is not as straightforward as it was for the studies discussed above. An across-the-board 10 per cent devaluation is measured as a 10 per cent decline in any index, no matter how the individual currencies are weighted. We shall assume, somewhat arbitrarily, that Artus-McGuirk's 10 per cent devaluation is very roughly equivalent to twice as great a decline (20 per cent) in the FRB dollar index, with respect to its impact on U.S. inflation, since a) the 10 countries included in the latter index account for only about half of U.S. trade and total world trade, and b) the currencies excluded from the FRB index, have tended to remain relatively constant on average against the dollar (or even move in the opposite direction of those included in the index). Based on this assumption, the MERM results suggest that a 10 per cent decline in our standard exchange rate index with no oil price response, would result in a 1.7-1.8 per cent increase in U.S. consumer prices.

[1/] The consumer price effects, not reported in Artus and McGuirk (1978), were provided separately by the authors.

2. The current version of the FRB's MIT-PENN-SSRC (MPS) model has been simulated to estimate the price effects of exchange rate changes.[1/] The MPS model takes into account (either in structural equations or in reduced form) all the partial-equilibrium effects outlined in our analytical framework. The international and price sectors, described in Thurman (1977), have been developed to the point where the exchange rate and foreign prices enter directly into domestic price determination. The trade sector has been completed and tested in simulation. A capital account sector also has been estimated (including the endogenization of the exchange rate) but has not been tested fully.[2/] A central feature of this structural model is that it allows for alternative monetary and fiscal policy assumptions.

Domestic prices are essentially determined in a markup equation that relates the fixed-weight nonfarm business deflator to labor wages, the import price deflator, exchange-rate-adjusted foreign prices,[3/] agricultural prices, labor productivity, the unemployment rate, and unfilled orders. The personal consumption expenditure (PCE) deflator is the closest approximation to the CPI in the Model. It is derived within a system of relative price

---

1/ These simulations were run by Steve Thurman, who assisted the authors considerably in making several modifications to the model and interpreting the simulation results.

2/ The implications of preliminary simulations of the MPS model with the endogenous exchange rate feature are discussed in Section IV below.

3/ Exchange-rate-adjusted foreign prices are included to capture changes in prices of domestically produced goods that compete with imports. Import prices are included in a specification that accounts for the lagged direct pass-through effects of the prices of imported finished and intermediate goods on the domestic price deflator. While import prices affect consumer prices in a positive direction in the model, they are included with a transitory negative effect (by construction) in the nonfarm business deflator equation since that deflator is a value-added deflator from which import prices are netted out. See Thurman (1977).

equations where the ratio of each sectoral deflator to the gross domestic sales deflator is related to the price determinants included in the nonfarm business deflator equation (including import prices) and several other variables.

Nonfuel import prices are determined by foreign prices, domestic competing prices and the exchange rate. The exchange rate is measured as a bilateral-trade-share-weighted average against ten major currencies. The exchange-rate elasticity in the nonfuel import price equation (pass-through coefficient) is 0.94 with an 8-quarter distrubuted lag. Nonagricultural export prices are determined within the system of relative price equations. In simulation the nonagricultural export unit value rose by 4 per cent following a 10 per cent depreciation. Less than half of this impact could be attributed to foreign competitive pressures; the rest of the impact was induced indirectly by the domestic inflationary effects of the depreciation. Nonagricultural export prices do not directly affect domestic consumer prices, but they do affect those prices indirectly through their impact on real net exports and aggregate demand. Fuel import prices and agricultural export prices are linked by historical ratios to the private nonfarm deflator (but were adjusted judgmentally in simulation.)

Estimates of the price effects of a dollar depreciation have been made on the basis of model simulations covering the period 1978 through 1980. These simulations were made under alternative policy assumptions. Also, judgmental adjustments were made for the impacts of the depreciation on foreign domestic prices and the prices of U.S. agricultural exports and oil imports. The simulations were partial-equilibrium in nature inasmuch as neither the factors causing the inital depreciation nor feedbacks to the exchange rate were taken into account.

The three alternative policy assumptions included: (1) a non-accommodating monetary policy (fixed M1 target), (2) an accommodating monetary policy (fixed Treasury bill rate target), and (3) a partially-accommodating monetary policy (fixed unborrowed free reserves target).[1/] For purposes of this exercise, we have translated the model's estimates which were obtained using the bilateral index into estimates consistent with the FRB's multilateral index (using the procedure described in Section II). Foreign prices were assumed to decline by 2/3 per cent following a 10 per cent dollar depreciation. The foreign price decline had the effect of reducing the U.S. PCE deflator by 0.3 per cent in the long run. Agricultural export prices were assumed to rise by 5 per cent following a 10 per cent depreciation, resulting in a 3-1/4 per cent increase in domestic agricultural prices and about a .3 per cent increase in the PCE deflator. Finally, oil import prices were assumed, alternately, to : (1) remain unchanged, and (2) rise in line with nonoil import prices.

The simulation results are summarized in Table 1. The Table lists the estimated percentage change in the PCE deflator after one year, two years, and three years resulting from a one-time depreciation of the dollar. Six simulation results are listed, for each of the three monetary policy assumptions both with and without an oil price response. The simulated effects of a 10 per cent depreciation range from a 0.5 per cent increase in the PCE deflator after one year [2/] to between a 1.2 per cent and 1.7 per cent increase after

---

1/ The partially-accommodating policy effectively held real GNP about unchanged from what it would have been in the absence of the depreciation.

2/ The one-year impact estimated by the MPS model is small relative to other estimates surveyed largely because of a relatively long distributed lag (eight quarters) on the exchange rate in the import price equation. If that lag structure had been constrained to four quarters rather than eight quarters to be more consistent with the results shown in Section II above, the estimated one-year impact of an exchange rate change on domestic prices would have been 50 per cent greater.

three years with no oil price increase and about .3 percentage ponts higher with an oil price response. The first-year impact largely represents short-term effects. The alternative effects after three years reflect the long-term aggregate demand impacts of nonaccommodating versus accommodating monetary policy. As indicated in the bottom row of the Table a reduction of aggregate demand is associated with the nonaccommodating (fixed M_1 target) case, whereas an expansion of aggregate demand is associated with the accommodating (fixed Treasury bill rate) case.

3. An estimate of the inflationary impact of the dollar depreciation between 1971:Q2 and 1974:Q2 was made in a study for the Joint Economic Committee by Berner, Clark, Enzler and Lowrey (1975), based on simulations with an earlier version of the MPS model. According to this estimate, the dollar's 13 per cent depreciation (as measured by the Commerce Department's bilateral-trade-weighted 67-currency index) during that period resulted in a 2.5 per cent increase in the CPI. This estimate can be translated into a 1.5 per cent increase in the CPI for a 10 per cent dollar depreciation on a multilateral-trade-weighted 10-currency basis.[1/]

The essential differences between this simulation and the more recent one are: (1) import and export prices did not enter directly into price determination in the earlier version of the model, instead their effects were treated judgmentally,[2/] (2) the relationship between exchange rates and

---

1/ The dollar depreciated by a little over 17 per cent on a multilateral weighted basis between 1971:Q2 and 1974:Q2.

2/ In the earlier study, total import prices were assumed to rise by a little over 60 per cent of the depreciation (80 per cent for agricultural imports and 60 per cent for all other imports). Agricultural export prices were assumed to rise by 80 per cent of the depreciation (as in the case of the more recent simulation). The large effect on prices of both agricultural exports and imports reflects the measurement of the dollar's depreciation against 67 currencies; for a depreciation in terms of the 10 country multilateral index, the rise in agricultural prices would be much smaller.

Table 1

Impact of a 10% Dollar Depreciation on Consumer Prices: MPS Simulation Results

Cumulative Impact on Personal Consumption Deflator After:	Oil Price Response[1/]			No Oil Price Response		
	Fixed M1 Target	Fixed Treasury Bill Rate	Fixed Unborrowed Free Reserves	Fixed M1 Target	Fixed Treasury Bill Rate	Fixed Unborrowed Free Reserves
1 year	.7%	.7%	.7%	.5%	.5%	.5%
2 years	1.3	1.4	1.4	1.0	1.1	1.1
3 years	1.5	2.0	1.8	1.2	1.7	1.5
Real GNP after 3 years	-.8	.5	-.2	-.6	.8	0.1

1/ Assumes 6 per cent increase in oil import price.

import and export prices as well as export volumes were also treated judgmentally, (3) the basic domestic price equation was more simplistic, with the nonfarm business deflator expressed as a function of wages and capacity utilization alone, (4) levels of capacity utilization and employment were somewhat higher in the early 1970's than during the more recent simulation period, (5) monetary policy (growth in base money) was assumed to follow its actual path during the earlier simulation, whereas it was adjusted to alternative paths in the more recent simulation, and (6) feedbacks from impacts of the depreciation on foreign price levels (which would tend to reduce the overall domestic inflationary inpact) were not taken into account in the earlier simulation.

Despite these differences, the estimate based on the Berner et. al. study is about the same as that implied by the fixed money target simulation using the more recent version of the MPS model.

IV. Empirical Estimates Based on Endogenous Exchange Rate Analysis

Few estimates are available based on structural models that treat the exchange rate endogenously. We consider two below.

1. The first involves preliminary work that has been done to endogenize the exchange rate in the MPS model, as described by Urdang (1978). In this version of the MPS model, equations have been added to explain U.S. demands for foreign assets and foreign demands for U.S. assets. Both asset demands are expressed primarily as functions of the exchange rate, relative interest rates, and various wealth proxies. The exchange rate is determined as a market clearing price that equilibrates the balance of payments (the sum of the trade balance and changes in U.S. and foreign private and official asset demands).

Foreign economies are still treated exogenously, so that feedback effects to the exchange rate are limited to U.S. domestic variables. However, preliminary simulations with the model have provided some interesting results. Most notably, under historical simulation with money growth unaltered by the depreciation, the model suggests that the depreciation of the dollar over the past year will have induced changes in the trade balance, aggregate demand, interest rates and other variables in the United States that eventually will lead to a partial reversal of the initial depreciation. With a fixed domestic money target, feedbacks from domestic variables would appear to reverse the estimated inflationary impact of the initial depreciation by as much as one-fourth.[1/]

1/ It should be noted that an important property of this model is that speculators do not fully anticipate the impact of these feedback effects on the exchange rate. The model does assume regressive exchange rate expectations (i.e., a depreciation will lead to a subsequent appreciation) but not rational expectations (i.e., expectations are not formed about the future paths of exchange rate determinants.)

2. A much more complete structural model of exchange rate determination has been developed by the International Quantitative Studies Section at the Federal Reserve Board (Berner, Clark, Hernández-Catá, Howe, Kwack, and Stevens (1977)). This general equilibrium multi-country model (MCM), is designed to trace the impact of changes in monetary or fiscal policy instruments or particular behavioral relationships on a wide variety of variables in each of 5 major countries[1/] plus the rest of the world. The model was estimated using quarterly data from 1964 through 1975, covering the period of both fixed and flexible exchange rates. The endogenous variables in the model include real and nominal GNP, export and import prices and volumes, domestic price deflators, wages, capacity utilization, unemployment, short and long-term interest rates and monetary aggregates for <u>each</u> of the countries included. The model captures all of the dynamic properties and feed-back effects that are described in our earlier discussion of the general equilibrium effects of exchange-rate changes. However, the model is still at a preliminary stage of development and only recently have the authors begun to evaluate its implications against prior information and judgmental analysis.

For the purposes of this exercise, it is useful to describe the price linkages in the model in some detail. There are explicit export-import price linkages as a given country's import prices depend upon the export prices of other countries, converted into local currency by current exchange rates. A country's domestic price deflator is a function of wages, import prices, capacity utilization and productivity. Its export prices of manufactured goods are determined by the same variables in addition to foreign competitiors' prices and exchange

---

1/ Canada, Germany, Japan, the United Kingdom and the United States.

rates. The prices of oil and other primary products are treated exogenously. Exchange-rate impacts are also present through the effects on net exports and aggregated demand, which influence capacity utilization and wage rates.

Finally, a central feature of the model is the inclusion of market-clearing mechanisms to equilibrate the demands and supplies of all goods and financial assets of the various countries. During the fixed exchange rate period, official reserve transactions are assumed to accommodate imbalances in net private transactions. In the floating rate period, exchange rates adjust to equilibrate the various demands and supplies, but it is recognized that central banks have intervened occasionally to moderate fluctuations in exchange rates. Reaction functions for exchange market intervention were estimated where possible. These discretionary interventions by central banks, together with all the other items in the balance of payments, jointly determine the bilateral dollar exchange rates of the 5 countries.

Because exchange rates are treated as endogenous variables rather than exogenous variables, analysis of the effects of exchange rate changes must be based upon model simulations in which one or more exogenous variable is shocked, resulting changes in both the exchange rate and domestic prices. A particular policy changes or shift in behavioral relationships causes adjustments in U.S. and foreign economic variables that can affect domestic prices independently of a change in exchange rates.[1/] In this context, then, it is more accurate to view the change in domestic prices as being "associated with" rather than "caused by" a change in exchange rates.

[1/] See the discussion on pages 10-14 above.

The estimates presented below are taken from model simulations (over the period 1973-75) involving first, a one-time change in monetary policy in Japan, second, a tightening of German fiscal policy and third, a shift in exogenous asset preferences between dollar-denominated assets and mark-denominated assets.[1/] U.S. monetary policy instruments are not altered during the simulation, with the exception that the impact of changes in U.S. net foreign assets on the monetary base is completely sterilized through open-market operations. The GNP path is not pegged by domestic policy auhtorities and is allowed to adjust to external shocks. Finally, exchange market intervention by the central banks of Germany and Japan to moderate fluctuations in their exchange rates is assumed to have only small effects on base money in those two countries.

In evaluating the results of these simulations two important factors should be kept in mind. One is that this model uses bilateral exchange rates directly so that a weighted-average rate must be derived. Because of different pricing behavior among countries and the varying importance of particular trading partners for the United States, the impact of a 10 per cent weighted-average depreciation of the dollar will have different effects on U.S. import and commodity prices depending upon the individual bilateral rates that are changed.

Second, the particular simulation exercises analysed here resulted in relatively small changes in the weighted-average value of the dollar.

1/ These and other simulation results are described in Hernández-Catá, Howe, Kwack, Stevens, Berner, and Clark (1979).

We have made a linear transformation of the simulation results in order to normalize the dollar depreciation to 10 per cent. This transformation may result in an understatement of associated domestic price increases because of nonlinearities in the model (in particular, aggregate demand and wages affect prices in a non-linear fashion). The transformed estimates for 4 and 11 quarters after the shock are shown below.

U.S. Domestic Price Increase Associated with a
10 per cent $ depreciation
(in per cent)

Shock	4 quarters after	11 quarters after shock
Tightening in Japanese monetary policy	.26	.8
Tightening in German fiscal policy	.77	.8
Shift in asset preferences from dollar-to-mark denominated assets	.92	1.5

The rise in domestic prices associated with a dollar depreciation following a monetary or fiscal shock was generally lower in the long run than that associated with an identical dollar depreciation following a shift in asset preferences. This can be explained by the fact that a monetary or fiscal tightening abroad has independent deflationary impacts on the U.S. economy that offset part of the inflationary effects of the depreciation. These deflationary impacts include, first, a moderation of foreign inflation, which offsets part of the depreciation-induced rise in U.S. import prices, and second, a reduction in foreign aggregate demand, which reduces U.S. aggregate demand through a decline in U.S. net exports.

There are differences between the short-run impacts of restrictive policies in Japan and Germany because Japanese exporters tend to raise their dollar export prices more slowly than German exporters in response to an appreciation of their currency against the dollar, but the long run effects in both cases are similar.

These estimates are limited by the fact that the MCM has not yet been simulated past eleven quarters. There are likely to be some continuing effects beyond three years after a shock. Also, because of the nature of the simulations that have been run, it is impossible to sort out changes in the exchange rate resulting from the initial shock from changes resulting from feedback effects.

IX. Summary and Conclusions

In this paper we first outlined the alternative analytical approaches that have been employed to estimate the effects of an exchange rate depreciation on domestic prices. Single-equation econometric models of domestic price determination capture the "price bloc" effects of a depreciation, including the direct effects of higher prices of imported intermediate and final goods and (implicitly) the indirect effects of upward pressure on the prices of domestically produced goods that compete with imports. These models may also capture some longer-term structural wage-price, aggregate demand and foreign price effects through the reduced-form treatment of wages and the inclusion of lagged import prices or a lagged dependent variable.

Input-output analyses have allowed for the effects of higher domestic prices of exported commodities whose prices are determined on world commodity markets, as well as a careful accounting of the direct effects of higher import prices by stage of processing. However, these models abstract from indirect (competitive) effects and longer-term structural effects.

Structural econometric models allow for one or more of the following (in addition to the price-bloc effects of higher import and export prices): 1) the effects of exchange rate changes on foreign prices, with feedbacks to domestic prices, 2) the effects of initial price increases on wages, with explicit feedbacks to prices, 3) the price effects of shifts in aggregate demand resulting from depreciation-induced changes in real net exports and 4) the response of monetary and fiscal policy authorities.

Endogenous exchange rate models allow for the independent inflationary impacts of exogenous factors causing the exchange rate change, as well as

feedbacks from depreciation-induced changes in domestic and foreign variables to the exchange rate itself.

Next we noted that there is no unique definition of a dollar depreciation. Changes in the dollar's foreign exchange value have been measured several different ways, using different weighted averages of individual bilateral exchange rates. We have chosen to translate alternative empirical estimates into the effects of a given average depreciation of the dollar as measured by the Federal Reserve Board's ten-currency multilateral trade-weighted index.

Summary of Alternative Estimates

The alternative estimates surveyed in this paper are listed in Table 2 below. The estimates are in terms of the effects of a 10 per cent multilateral-weighted-average dollar depreciation on the level of consumer prices, assuming first, that oil import prices are not affected by the depreciation and second, that they rise by the same proportion as nonoil import prices as a result of the depreciation. In a number of models, the timing of the domestic price effects is not explicit (and may vary substantially when oil price reactions are taken into account), but they generally take place distributed over a period of two years or more following a depreciation.

The estimates are fairly consistent within each approach. The single equation estimates are generally somewhat lower than the structural model estimates. This may reflect empirical differences between reduced-form and structural estimation of wage-price effects. The WPP estimate is on the low side because it is strictly a short-term (one-year) estimate and excludes all wage-price effects. The Dornbusch-Krugman estimate is on the high side among single-equation results, possibly because their specification excluded one or

Table 2

Summary of Alternative Estimates of the Impact of a 10 per cent Dollar Depreciation (multilateral weighted-average basis)[1/] on the U.S. Consumer Price Level

	Percentage Increase in Consumer Prices	
	Without Oil Price Response	With Oil Price Response
I. Exogeneous Exchange Rate		
A. Single Equation		
1. Dornbusch and Krugman	1.7	2.2
2. Modigliani and Papademos	1.1	1.4
3. Spitaller	1.1	1.4
4. WPP	.8	1.1
B. Input-Output Approach		
1. Isard	--	.8
2. Nordhaus-Shoven	--	.9
C. Simplied Structural		
1. Prakken	1.5	--
2. Kwack	--	2.7
D. Structural		
1. MERM (Artus-McGuirk)	1.7 - 1.8	--
2. MPS (Thurman)	1.2 - 1.7	1.5 - 2.0
3. JEC study (Berner, et. al.)	--	1.5
II. Endogeneous Exchange Rate		
1. MPS	.9	1.2
2. MCM	.8 - 1.5	--

more of the domestic price determinants that were included in other single-equation models. The excluded variables may have been correlated with import prices and caused an upward bias in the estimated import price coefficient.

The input-output estimates are somewhat lower than the single-equation estimates, because (a) input-output coefficients do not allow for

---

1/ FRB index. These estimates would be roughly 50 per cent greater in the case of a 10 per cent depreciation on a bilateral weighted-average basis. The estimated "pass-through" coefficient from exchange rates to import prices is .57 using a multilateral exchange rate index and .88 using a bilateral index if oil prices respond. The "pass-through" coefficients are .43 and .66 respectively, if oil prices are not affected. See Section II above.

competitive price effects,[1/] (b) wage-price effects are excluded, and (c) the dynamic adjustment allowed for in most single equation models may capture additional effects that static input-output models would not.

The estimates based on simplified structural models are generally larger than those based on single equations because at a minimum they account for structural wage-price feedbacks in addition to the effects outlined above. The Kwack estimate is on the high side partly because of a very high estimated elasticity of import prices with respect to exchange rates (import prices are estimated to rise by proportionately more than the decline in the exchange rate).

Among the full structural model estimates, the MPS results are presented in ranges reflecting alternative policy assumptions. The high estimate in each range is based on an accommodating monetary policy (fixed interest rate target) which allows aggregate demand to rise. The low estimate is based on a nonaccommodating policy (fixed money growth target), which raises interest rates and reduces real aggregate demand. An intermediate policy stance such as a fixed real GNP target yields an intermediate estimated impact, which, ceteris paribus, would be roughly equivalent to a simplified structural estimate in which real GNP is treated exogenously. The MERM estimate also is given in a range, because of uncertainty concerning the translation of the MERM exchange rate assumption into the index we have selected.

The endogenous exchange rate estimates are smaller than the structural model estimates. In the endogenous MPS estimate, this difference reflects feedbacks from domestic variables to the exchange rate under a fixed money growth assumption. This estimate is roughly .3 percentage points below the low exogenous MPS estimate, which was also based on a fixed money growth

---

[1/] Except in homogeneous commodity markets.

assumption. These feedback effects would be smaller under a fixed interest rate or intermediate monetary policy assumption, since the rise in interest rates following a depreciation would be smaller and have less impact on the exchange rate.

The alternative estimates based on MCM reflect the independent price effects of alternative factors causing the initial exchange rate change. The lower estimate represents the effects of an exchange rate change that was caused by a tightening of foreign monetary policy. The foreign monetary shock put downward pressure on foreign prices, which offset part of the upward pressure on domestic prices resulting from the depreciation. The higher MCM estimate represents the effect of an exchange rate change induced by an exogenous shift in foreign asset preferences, which had little independent offsetting effect on domestic prices.

Consensus Estimate

A primary purpose for undertaking this survey was to obtain a "consensus estimate" of the price effects of a dollar depreciation. One outcome of our survey has been a better understanding of the partial-equilibrium nature of the question, which treats the exchange rate as the causal factor. Any answer to this question must be reconciled with a more complete (and accurate) view of the world, in which exchange rates are in fact determined by other variables. Before proposing an answer, therefore, we must caution that it will apply only to exchange rate changes that are caused by exogenous factors that do not have significant independent effects

on domestic inflation. Such exchange rate changes can be very roughly approximated by relative-price-adjusted or so-called "real" exchange rate changes.[1/]

The consensus estimate we propose, based on the estimates listed in Table 2, is that a given 10 per cent real dollar depreciation on a multilateral weighted average basis will result in 1-1/2 per cent increase in the consumer price level, assuming an intermediate policy stance (fixed GNP target), if oil import prices are not affected by the depreciation, and by 1-3/4 per cent if oil import prices rise by the same proportion as nonoil prices in response to the depreciation.[2/] Given the time frame of the various models considered, about half of the total impact is likely to take place within one year and the remainder within 2-3 years following the depreciation, although the timing of the oil price effects may be more variable because of the discontinuity of OPEC pricing decisions.

Implications for the Inflationary Impact of the Recent Dollar Depreciation.

These multiplier estimates imply that the 15 per cent price-adjusted depreciation of the dollar from the fourth quarter 1976 to the fourth quarter 1978,[3/] if it is sustained, eventually will raise U.S. consumer prices by

---

1/ The accuracy of this approximation diminishes as the exchange rate change is spread out over time, since domestic and foreign prices will begin to reflect the consequences of exchange rate developments. For a description of price-adjusted exchange rates, see Hooper and Morton (1978) pp. 787-789.

2/ That is, if both oil and nonoil import prices rise by 5.7 per cent following the 10 per cent multilateral weighted average depreciation.

3/ As measured by the multilateral weighted average foreign currency value of the dollar divided by the ratio of a multilateral weighted average index of of foreign consumer prices to U.S. consumer prices.

2-1/4 to 2-2/3 per cent above the level they would have attained if the depreciation had not taken place, ceteris paribus. The higher estimate assumes that about half of the recently announced 14 per cent OPEC price increase can be attributed to the depreciation of the dollar; the lower estimate assumes that the depreciation will have had no effect on oil prices and that the recent OPEC increase was imposed for other reasons. Given the pattern of the dollar depreciation spread over the past two years, about half of the nonoil price effect would have taken place by the end of 1978.

The importance of the ceteris paribus assumptions underlying these estimates cannot be stressed too much. We have assumed that the exchange rate could have been held constant without changing other variables that would have affected domestic prices. This could have occurred, for example, if asset holders had wished to hold larger amounts of dollar-denominated assets, thus helping to finance the U.S. current account deficit at an unchanged exchange rate. However, if policy measures such as exchange market intervention, monetary tightening or trade restrictions had been adopted to keep the dollar from depreciating, these measures would have influenced the pattern of domestic prices independently of their impact on the exchange rate. For example, a policy of restricting imports in order to stabilize the exchange rate by reducing the trade deficit would have been inflationary in its own right, so that some of the price effects we have attributed to the depreciation of the dollar still would have occurred.

Finally, we have assumed implicitly that domestic economic policies pursued during the period of adjustment to the depreciation will have roughly offset any tendency for the path of real aggregate demand to change as a result of the depreciation. Different policy responses would alter the pattern of domestic price changes.

Bibliography

Artus, J. R., and A. K. McGuirk. "A Revised Version of the Multilateral Exchange Rate Model." Preliminary draft. Washington: International Monetary Fund, May 1978.

Berner, R., P. Clark, J. Enzler, and B. Lowrey. "International Sources of Domestic Inflation," Studies in Price Stability and Economic Growth, Papers No. 3 and 4, International Aspects of Recent Inflation. Joint Economic Committee. 95th Cong., 1st sess. Washington: Government Printing Office, 1975, pp. 1-41.

Berner, R., P. Clark, E. Hernández-Catá, H. Howe, S. Kwack, and G. Stevens. "A Multi-Country Model of the International Influences on the U.S. Economy: Preliminary Results," International Finance Discussion Papers No. 115. Washington: Board of Governors of the Federal Reserve System, December 1977.

Board of Governors of the Federal Reserve System, Division of Research and Statistics, Wages, Prices and Productivity Section. "Impact of the Recent Currency Devaluation on Prices." Preliminary draft, February 1978.

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

Dornbusch, R., and P. Krugman. "Flexible Exchange Rates in the Short-Run." Brookings Papers on Economic Activity 3:1976, pp. 537-75.

Hernández-Catá, E., H. Howe, S. Kwack, G. Stevens, R. Berner, and P. Clark. "Monetary Policy under Alternative Exchange Rate Regimes: Simulations with a Multi-Country Model," Managed Exchange Rate Flexibility: The Recent Experience. Proceedings of a conference. Boston: Federal Reserve Bank of Boston, October 1978.

Hooper, P. "Forecasting U.S. Export and Import Prices and Volumes in a Changing World Economy," International Finance Discussion Papers No. 99. Washington: Board of Governors of the Federal Reserve System, December 1976.

Hooper P., and J. Morton. "Summary Measures of the Dollar's Foreign Exchange value." Federal Reserve Bulletin, vol. 64 (October 1978), pp. 783-89.

Isard, Peter. "Domestic Price Effects of Exchange Rate Changes." Washington: Board of Governors of the Federal Reserve System, March 1974; processed.

Kwack, Sung Y. "Price Linkage in an Interdependent World Economy: Price Responses to Exchange Rates and Activity Changes," Analysis of Inflation 1965-1974. Joel Popkin, ed., Cambridge, Mass.: National Bureau of Economic Research, Inc., 1977, pp. 447-76.

Levy, M. "International Influences on U.S. Inflation, 1971-1976." Mimeograph prepared for the Department of Commerce, Contract No. 6-36234, New York, September 7, 1977

Modigliani, F. and L. Papademos. "Targets for Monetary Policy in the Coming Year." Brookings Papers on Economic Activity 1975, pp. 141-66.

Nordhaus, W., and J. Shoven. "Inflation 1973: The Year of Infamy." Challenge vol. 17 (May/June 1974), pp. 14-22.

Prakken, J. "Exchange Rates, Import Prices and Domestic Inflation," Mimeograph. Federal Reserve Bank of New York, 1978; processed.

Spitaller, E. "An Anaylsis of Inflation in the Seven Main Industrial Countries 1958-1976." IMF Staff Papers, Vol. 25, No. 2 Washington: International Monetary Fund June 1978, pp. 254-77.

Thurman, S. S. "The International Sector" and the "The Price Sector" of the MPS model. Board of Governors of the Federal Reserve System, April 1977; processed.

Thurman, S. S., and S. Y. Kwack. "Linking the MPS Price Sector to International Price Disturbances." International Finance Discussion Papers No. 85. Washington: Board of Governors of the Federal Reserve System, July 1976.

Urdang, E. S. "An International Flow of Funds Model with an Endogenous Exchange Rate. Ph.D. dissertation in progress, University of Pennsylvania, March 1978.