LINKING THE MPS PRICE SECTOR TO INTERNATIONAL PRICE DISTURBANCES

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Stephen S. Thurman and Sung Y. Kwack*

A central feature in the respecification of the price sector of the Federal Reserve's MPS model is the attempt to estimate the direct and indirect effects of external sources of domestic inflation on the U.S. economy and to include these effects systematically in the model's aggregate price-determining mechanism. The key assumptions underlying this attempt are that the U.S. economy is open to externally originating price disturbances and that the U.S. price-determining process does not occur in isolation, but rather is included in a reverberation process of increasingly interdependent world price linkages.

In their report to the Pacific Basin Central Bank Conference held in San Francisco last year, Clark and Enzler [2] presented an overview of the basic structure of the MPS model. The also indicated how a crudely modified version of this model could be used to simulate external shocks to the U.S. domestic price sector. Towards the end of that presentation they discussed future modifications and extensions of the MPS model which were proposed to systematize the international forces operating in the domestic economy. Section I of this paper will review our thinking to date on how these forces should be considered within the context of a price sector of a large domestic macroeconomic model. Section II will present the specification and preliminary estimates of the new MPS price sector. Section III will conclude with an outline of our research strategy for closing the international economic linkage process from the standpoint of the MPS model.

*The views expressed herein are solely those of the authors and do not necessarily represent the views of the Federal Reserve System.

The price equations presented here are initial results from a reestimation of the MPS price sector undertaken as Mr. Thurman's dissertation research at the Department of Economics, George Washington University. Both authors conducted the simulations and analysis. A preliminary version of this paper was presented at the Second Pacific Basin Central Bank Conference on Econometric Modeling held on June 8-11, 1976, Seoul, Korea.
Section I

To evaluate the effects of externally originating sources of domestic inflation, let us imagine the response of the domestic economy to an increase in foreign prices or an effective depreciation of the U.S. dollar. We have divided these effects into four categories for discussion purposes.

1. Direct Balance of Payments Effects: A rise in the prices of imported goods and services will cause the real value of expenditures on imports to fall. The prices of domestic exported goods, including services, relative to foreign competing goods will fall which will induce demand for and subsequent real expenditures on exported goods to rise. Hence, the goods and services account balance will improve for the domestic economy. This improvement will eventually strengthen the value of the domestic currency in foreign exchange markets.

2. Passthrough Effects from the Foreign Sector to the Domestic Price Sector: Direct passthroughs of higher import prices by domestic retailers to domestic buyers of final goods increases the value of purchases by ultimate consumers in the short run. Lagged passthroughs of imported intermediate goods prices temporarily reduce business profit margins of domestic producers using imported production inputs. Import-competing goods producers now feel more free to raise competing goods prices. Producers of export goods will be encouraged by their new strength in markets abroad to raise the prices of the goods that they produce which are also consumed domestically. Domestic producers of close substitutes to these export goods will also feel free to increase prices. Increased profit margins in the domestically traded goods industries will eventually attract new firms to these markets, thus having a mitigating influence on price increases in these industries.
3. **Indirect Domestic Macroeconomic Effects:** A general increase in consumer prices will reduce the real net worth positions of domestic households, which has a depressing influence on consumption expenditures. Wage earners, now faced with increasing prices, will seek increased wages to maintain their standard of living. These increased wage demands shift upward the short-term Phillips curve and exert further upward pressure on the price level. The direct rise in traded goods prices, along with an induced rise in domestic sector prices will lead to an increase in the demand for nominal money balance by increasing the total value of economic transactions. If monetary aggregates are not allowed to rise in an accommodating fashion, interest rates will increase. Higher interest rates will tend to hold down real output and will also attract inflows of capital from abroad, which will lead to an appreciation of the value of the domestic currency in foreign exchange markets.

4. **Domestic-Foreign Price Reverberations:** The general rise in domestic prices, and the macroeconomic responses to the external inflationary forces, are retransmitted to the foreign domestic economies with which the United States directly and indirectly trades. These retransmissions are received by the foreign economies through increasing U.S. export (foreign import) prices, reduction in U.S. demand for imports (foreign exports), and shifts in capital flows towards the U.S. According to its own structure and degree of openness to external stimuli, each foreign economy will likewise be affected by the change in U.S. current account conditions. These foreign domestic reactions in turn will be retransmitted back to the U.S. economy.

The inflation transmission mechanisms discussed above contain simplifying assumptions, which were made for purposes of exposition. These include an implicit dynamic-statics for the domestic rest-of-world price reverberations and the assumption that the initial inflationary shock originated exogenously to the domestic
price system. In reality—and this will be approximated in our final model—
reverberations are dynamically interactive with, and endogenous to, the domestic
system.

Section II

In early MPS model studies of external sources of domestic inflation the
model presented two major deficiencies. The first source of consternation was
that all impact and lagged foreign price effects were absent in the model equa-
tions and required extensive judgmental adjustment. Second, foreign inflationary
disturbances, judgmentally fed into the model's sector price deflators, could not
be guaranteed to be consistently applied to the production and expenditure accounts
measurements such that the economy's income identities would compute consistent
amounts. A "mix" problem of misallocation of sector price changes would have to be
adjusted by a constant blow-up factor to insure consistency.

The restructured domestic price sector attempts to maintain the incomes account
consistency by estimating a fixed weight general nonfarm business deflator as the
dominant price equation in the model along with sector deflators weighted and relative
to the general fixed weight deflator. Included in the specifications of the general
and relative price equations are foreign exchange rate adjusted prices relative to
domestic prices.

The consistency requirements for the allocation of impacts to the price sector
are met by the following system.

\[ p = \sum_{i=1}^{m} w_i p_i, \quad \sum w_i = 1, \quad w_i \geq 0, \text{ for } i = 1, 2, \ldots, m \text{ sectors of the economy} \]

\[ p = \alpha + BZ + \gamma p_f \]

\[ \frac{w_i p_i}{p} = \alpha_i + B_i Z + \gamma_i p_f, \]
where \( P \) and \( p_i \) are the general fixed weight and sector deflators respectively.

A fixed weight \( w_i \) is a constant historical ratio of the \( i \)th expenditure sector to total expenditures. \( Z \) is a vector of domestic activity variables and \( P_f \) represents a vector of foreign prices. From the above system we have the properties

\[
\sum_{i=1}^{m} \alpha_i = 1, \quad \sum_{i=1}^{m} B_{ij} = 0, \quad \sum_{i=1}^{m} \gamma_i = 0
\]

Equation (4), the "summing constraints", guarantees consistent sector price changes with respect to a constant or changing general fixed weight price deflator; for example:

\[
\frac{\partial P}{\partial P_f} = \sum_{i=1}^{m} w_i \left( \frac{\partial p_i}{\partial P_f} \right)
\]

The above means that within the context of a large nonlinear econometric model the change in the production side of the economy (call it the source of value added), brought about by a shift in a determinant variable, will be consistent with the national income accounts expenditure side (call it the ultimate use by sector of the source of value added). This achieves a consistent set of price deflators and eliminates the "mix" problem of inconsistent allocation of impacts between the production and expenditure accounts that results in either the direct case of an impact estimated within the system (\( \Delta Z \) or \( \Delta P_f \)) or the indirect case of a change in some other domestic variable affecting \( Z \).

To derive the specification of the estimated equations in the MPS framework we start by introducing a vector of value added outputs equal to a vector of final demands with "\$" denoting current dollar values:
\[ (6) \quad XBNF\$ + XBF\$ + EIM\$ + YH\$ = ECND\$ + ECD\$ + EH\$ + EPD\$ + EPS\$ + EGSC\$ + EGSO\$ + EGFC\$ + EGFO\$ + EEX\$ \]

where

\[ \begin{align*}
ECND\$ &= \text{expenditures on consumer nondurables} \\
ECD\$ &= \text{expenditures on consumer durables} \\
EH\$ &= \text{expenditures on residential housing} \\
EPD\$ &= \text{expenditures on producers' durable equipment} \\
EPS\$ &= \text{expenditures on producers' structures} \\
EGSC\$ &= \text{expenditures on state & local government construction} \\
EGSO\$ &= \text{expenditures on state & local government nonconstruction enterprises} \\
EGFO\$ &= \text{expenditures on federal government construction} \\
EGFC\$ &= \text{expenditures on federal government nonconstruction enterprises} \\
EEX\$ &= \text{foreign expenditures on U.S. exports} \\
XBF\$ &= \text{value of farm business output} \\
EIM\$ &= \text{domestic expenditures on imports} \\
YH\$ &= \text{household income} \\
XBNF\$ &= \text{value of nonfarm business output}. \\
\end{align*} \]

Rewriting equation (6) with the industry and final demand implicit deflators and expressing in terms of the nonfarm business sector yields

\[ (7) \quad XBNF \cdot PXBNF = ECND \cdot PCND + ECD \cdot PCD + EH \cdot PEH + EPD \cdot PPD + EGFC \cdot PEGFC + EGFO \cdot PEGFO + EEX \cdot PEEX - XBF \cdot PXBF - EIM \cdot PEIM - YH \cdot PYH \]

The fixed weight general nonfarm business deflator, PXPFW1, is calculated by weighting the right-hand side deflators with the ratio of the base year 1972 real
values of the right-hand side expenditure levels to XBNF to get the $w_i$'s in equation (1):

\[ PXPFW1 = 0.65107*PCND' + 0.11659*PCD' + 0.064899*PEH + 0.077775*PPD \\
+ 0.044529*PPS + 0.027618*PEGSC + 0.039057*PEGSO \\
+ 0.0046335*PEGFC + 0.049895*PEGFO + 0.076099*FEEX \\
- 0.03356*PXBF - 0.079429*PEIM - 0.038979*PYH \]

PXPFW1 differs from PXBNF as federal indirect business taxes effects were purged from PCND and PCD to reflect the fact that excise taxes add nothing to value added, although they are directly passed on to prices purchasers pay for goods.

The functional form explaining PXPFW1 is conceptually the same as the previous MPS nonfarm business deflator equation as described in De Menil and Enzler [5]:

\[ PXPFW1 = f(PL, UOS, OMH, PRFD, PWM) \]

PL is the domestic nonfarm wage rate representing labor costs which will be assumed to be passed on directly to prices. Consequently unitary labor costs will be forced in estimation.

UOS is the ratio of unfilled orders to a moving average of shipments of producers' durable equipment \( (\sum_{i=0}^{3} EPD_i / 4) \). This variable is designed to reflect the degree of demand elasticity affecting the markup policy of the oligopolist producer. When this ratio is high, orders are backlogged and demand is strong. The net positive effect here is estimated with a current and lagged term. This variable is similar to the capacity utilization measures \( (XB/XBC) \) ratio of business output to business capacity) used in other models and later to be seen in conjunction with UOS in the relative price equations below.
OMH is output per manhour in the nonfarm business sector, namely the ratio of nonfarm business output (XBNF) to total manhours (LMHT). This variable enters in estimation as a distributed lag with the rationale that technical progress is Harrod neutral over a relatively long time horizon. The lagged coefficients, together with the lagged dependent variable need to be forced to unity.

PRFD represents exchange rate adjusted foreign wholesale prices relative to domestic prices \((PFXW*FPWIW/PXPFW1)\) where PFXW and FPWIW are the foreign effective exchange rate and foreign wholesale price indexes, respectively, weighted by averaged bilateral and multicountry import value shares. This foreign to domestic price linkage effect will be assumed to enter with a lag process.

FWM, a price of world materials, is entered to represent a transitory impact in the cost passthrough process of oligopolist pricing decisions. It is expected that the effect is initially negative because the passthroughs take time to occur before a positive impact is felt later on. The MPS variables used to proxy FWM were of the form \((.7PEIM + .3PXBH)\).

In general, one would expect there would not be much time lag in the adjustment of the output price by a firm to a change in its costs. The aggregative price includes the prices of outputs of some firms which are inputs to others. Those firms using the intermediate goods adjust their prices slowly for the increased cost of the intermediate goods. Consequently a lagged adjustment process of the Koyck type is assumed.

The specification for the PXPFW1 equation (analogous to equation (2)) is:
Table I: Non-Farm Business Deflator Equation (EPFWL)

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<th>Variable</th>
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<th>Standard Error</th>
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<td>b</td>
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<td>(10.79)</td>
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<tr>
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<tr>
<td>(\Sigma l_1)</td>
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<td>(2nd degree polynomial)</td>
</tr>
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</table>

\[ R^2 = 0.9995 \]  \[ Se = 0.0028 \]  \[ DW = 2.057 \]  \[ \rho = 0.2 \]
\begin{equation}
\ln(\text{PXPFWl}/\text{PL}) = a + b \ln(\text{PXPFWl}_{-1}/\text{PL}) + \sum_{i=0}^{3} c_i \Delta \ln(\text{PM}_i)_{-1} \\
+ d_1 \text{UOS} + d_2 \text{UOS}_{-1} + \sum_{i=0}^{6} f_i \ln(\text{OMR}_i)_{-1} \\
+ g \text{CONT} + h \text{DUME} + \sum_{i=0}^{15} l_i \Delta \ln(\text{PRFD}_i)_{-1}
\end{equation}

CONT is a vector of estimated price residuals entered to net out the relative impacts of the phases of the price controls period from 1971:3 to 1973:4. DUME is a dummy variable to account for missing lagged foreign exchange rate and price data prior to 1957:1.

The equation was estimated for the period 1958:1 to 1974:4 using restricted least squares with a scanned autoregressive scheme that minimized the sum of squared errors. Almon polynomial distributed lag coefficients were estimated for the lagged variables, constrained to 0 at the end of the period. The estimated coefficients are given in Table I. Figures in parentheses are t-ratios. \( \circ \) is the coefficient of the first order serial correlations.

In formulating the relative price equations it was obvious that not all of the sector prices on the right-hand side of the definition of PXPFWl would respond to the markup over minimized cost functional form. Specifically, PEIM, PXBF and PHY were considered to respond to significantly different forces than those of the nonfarm business sector. Consequently a gross domestic sales fixed weight deflator is introduced as:

\begin{equation}
\text{PXPFW2} = .56513*\text{PCND}^1 + .10112*\text{PCD}^1 + .056322*\text{PEH} + .067509*\text{PPD} \\
+ .038651*\text{PPS} + .023972*\text{PEGSC} + .033902*\text{PEGSO} \\
+ .0040219*\text{PEGFC} + .043309*\text{PEGFO} + .066054*\text{PEEX}
\end{equation}
The right-hand side weights (call them $v_i$) for each $p_i$ are calculated by the ratio of each historical real 1972 base sector expenditure level to the total of all real 1972 base expenditures. PXPFW2 and PXPFW1 are therefore related by the identity:

$$\text{PXPFW2} = \text{PXPFW1} + \sum_{i=1}^{10} (v_i - w_i) p_i + \sum_{i=11}^{13} w_i p_i$$

Using a similar functional form as that of the general nonfarm business fixed weight deflator equation (10), the specification for the relative price equations for each $p_i$ is as follows:

$$\frac{v_i p_i}{\text{PXPFW2}} = a + a_1 \frac{\text{PEIM}}{\text{PXPFW2}} + a_2 \frac{\text{PXBF}}{\text{PXPFW2}} + a_3 \frac{\text{PYH}}{\text{PXPFW2}} + b_1 UOS$$

$$+ b_2 UOS_{-1} + \sum_{i=0}^{3} c_i (X/B/XBC)_{-i} + \sum_{i=0}^{11} d_i \ln(OMH)_{-i}$$

$$+ h \times \text{CONTR} + (e + \rho e_{-1})$$

$X/B/XBC$ is a proxy for the capacity utilization rate and $\text{CONTR}$ is a simple binary dummy variable for the price controls period (1 from 1971:3 to 1973:4, 0. otherwise).

The values for coefficients of the sector prices ($\text{PEIM}$, $\text{PXBF}$, $\text{PYH}$) which were not included in $\text{PXPFW2}$ can be derived a priori from the expression:

$$a_{ki} = \frac{X_k}{T-X_k} (\alpha_{ki} - v_i) \quad k = 1, 2, 3$$
where $X_k$ is the historical real value added output of the omitted value added sector $k$,

$T$ is the total of the final demand expenditure sections, the denominator in calculating the PFXFW2 weights; $T = \sum_{j=1}^{10} X_j$,

$v_i$ is the PFXFW2 weight $v_i = X_i / T$ for the $i^{th}$ sector, and

$\alpha_{ki}$ is the proportion of the $k^{th}$ omitted value added output sector consumed in the $i^{th}$ final demand sector.

The $\alpha_{ki}$ are derived from the dual of the "C" matrix used in an input-output analysis described in Preston [8]. The "C" matrix derives coefficients to express the proportion of final demand vectors that come from a vector of value added sector outputs. Here we are interested in the proportion of value added output "consumed" totally in the vectors of final demand. This concept yields the relative impacts of the omitted value added output deflators on the included final demand deflators. These impacts are weighted such that the total impact across the system sums to zero thereby preserving the system summing constraints.²/

The estimates for the ten relative price equations are contained in Table II. The equations were estimated using ordinary least squares with a specified autoregressive coefficient to preserve the summing constraints yet correct for the average serial correlation in the disturbances across equations. All lagged variables are Almon polynomial distributed lags. Both lag structures were 2nd degree constrained to 0. at $t-n$. Figures in parentheses are $t$-ratios. The values of $a_{ki}$, as mentioned above, were imposed.

As in most of these sum constrained systems the estimated coefficients are to be interpreted as impacts on the weighted relative variable. The impact upon the level of each sector deflator is not immediately apparent. Similar to equation
(14) we can derive an approximation to the implied level impact from the expression:

$$\delta_{ki} = \frac{\hat{B}_{ki} + v_i \hat{B}_k}{v_i}$$

(15)

where $\delta_{ki}$ is the approximated impact of the $k^{th}$ right-hand side variable on the $i^{th}$ sector deflator.

$\hat{B}_{ki}$ is the estimated coefficient of the $k^{th}$ right-hand side variable in the $i^{th}$ sector equation.

$\hat{B}_k$ is the impact on the weighted average price, PXPFW2, derived from $k^{th}$ variables' impact on PXPFW1 and each $p_i$ in equation (12).

Equation (15) is a nontrivial reminder to those who would attempt to interpret the estimated (or imposed) right-hand side coefficients. The $\hat{B}_{ki}$ for any $i^{th}$ sector equation may, at first glance, appear to have the "wrong sign". The impact $\delta_{ki}$ on the $i^{th}$ equation, however, also takes into account the sector weight $v_i$ and the total system impact $\hat{B}_k$. Therefore, the impact $\delta_{ki}$ should conform to the theoretical expectations.

Of specific interest to this conference as well as policy makers are the impacts of foreign price and exchange rate shocks on domestic prices and activities. To calculate the impact on domestic prices, we performed two sets of simulations over a three year period (1968 to 1970): the first with the price sector alone and the second with the price-wage sectors jointly. These simulations assumed a shock of a 1 percent depreciation of the weighted foreign exchange rate index (0.01 for the base year 1972=1). This shock feeds into the model through three channels: the main price equation (10), the estimated equation for the unit value index for nonfuel imports which affects FEIM, and an adjustment on farm product exports deflator affecting PXBF.
Table III presents the simulation results for the price sector alone. The numbers in the table are percent changes in the level of each deflator. For example, the one percent exchange rate depreciation increases gross domestic sales fixed weight deflator PXPFW2 by slightly more than 0.1 percent at the end of three years. On the whole, we expect the sector price deflators that have the higher direct and indirect foreign trade components, as indicated by the coefficients $\alpha_{ki}$ in equation (14), to show greater impacts than the weighted average, PXPFW2. This is evidenced in the impacts on PCD, PPD, and PEEX. The impacts on PCND are surprisingly less than the average. This may indicate that the pass-through effect has not been fully captured in the price system for this sector. PPS, a representative expenditure sector deflator that has a small foreign component, has correspondingly lower than the average impact multiplier. The impacts on PEIM and PXBF reflect the assumed direct influence of world market pricing and exchange rate movements.

The further inflationary pressure brought about by the wage-price interaction of the Phillips curve mechanism in the MPS model was the object of the second simulation. The results are presented in Table IV. We see here the higher value of impacts across all of the deflators resulting from the interaction of the price deflators with the wage rate, PL. This result is in line with the findings of Kwack [4]. At the end of the three year simulation period, the change of 0.29 in the wage level represents a .06 percent change in PL. The 0.06 percent increase in PL was fed into the price sector, resulting in a 0.06 percent increase in the level of PXPFW2. The multiplier effect on PXPFW2 of a one percent depreciation is slightly more than a 0.15 percent increase, which is higher than the non-wage induced increase of 0.11 percent in the first simulation. The pattern of changes in the levels of the sector deflators relative to PXPFW2 is similar to that of the first simulation, as expected.
Table III: MPS Price Sector Simulations
With a 1% Increase in the Exchange Rate Index

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<th>PXFM2</th>
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1. Figures are percent changes in price deflators due to an increase of 0.01 in the exchange rate index.

2. The 1972 base year price deflators are equal to 100, whereas the 1972 base year exchange rate index is equal to 1.
Table IV: MPS Price and Wage Sector Simulations
With a 1% Increase in the Exchange Rate Index

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1. Figures are percent changes in price deflators (1972=100) and the value of PL (for 1972, PL = approximately 465), due to an increase of 0.01 in the exchange rate index.

2. The 1972 base year exchange rate index is equal to 1.
FOOTNOTES

1/ This expression is derived from \( \Delta R_k \left( \frac{\nabla_i p_i}{\nabla_i p_{k\text{FW}}} \right) / \Delta R_k \left( \frac{R_k}{\nabla_i p_{k\text{FW}}} \right) \)

where \( \Delta R_k = \partial / \partial p_k \).

2/ The derived \( \lambda k_i \) used in calculating the \( ak_i \) in vector notation for the three omitted value added sectors were EIM (.336, .168, .029, .176, .034, .0042, .0059, .0176, .1885, .0401), XBF (.615, .01, .019, .025, .013, .008, .017, .001, .015, .276), YH (1.0, 0., 0., 0., 0., 0., 0., 0., 0., 0.).

Our thanks is due to Ros Preston and Gene Guill for providing the updated C mature coefficients for the 1972 base year.
REFERENCES


