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by

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The Effects of Foreign Inflation on Domestic Prices and the Relative Price Advantage of Exchange Rate Changes

by

Sung Y. Kwack*

Since the exchange rate realignments of major currencies in the world in the last few years, major industrial countries have experienced substantially higher-than-average rates of inflation in the 1960's. Consequently, there is considerable interest in the effects of external inflation on domestic prices. Several studies, notably by Branson [2] and Clark [4], discussed the effects on the U. S. trade account of the exchange rate realignment. The common assumption in these studies is that the increase in import prices relative to domestic prices resulting from a currency depreciation equals the rate of depreciation. While recognizing the weakness of this assumption, they, nevertheless, introduced the assumption in the absence of information on the induced changes in domestic prices.

The purpose of this paper is to test a model of price determination in an open economy in which we estimate the effects of external prices on domestic prices and the effects of exchange rates on the relative price advantage, measured by import prices relative to domestic prices. The main result of the analysis is that the rate of import price inflation contributes significantly to the rate of domestic inflation when its indirect effect on domestic prices, which operates via induced changes in money wage rates, is taken into account. Consequently, the improvement in the relative price advantage is less than the rate of depreciation.[1/]

Part I of this paper presents a model determining the rate of price inflation which explicitly includes the role of import prices. Part II tests the model with annual data from 1959 through 1971 for two regions, the United States and the major foreign industrial countries. Part III presents some estimates of the effects on the U. S. and foreign rate of inflation and U. S. relative price advantage of a U. S. dollar devaluation. These estimates are based on the empirical results for two regions. Part IV summarizes the main empirical findings.

I. THE MODEL

It is well-known that international trade tends to diminish price differentials existing between trading countries. This is more apparent when imports are close substitutes for domestically produced goods. We will set out two obvious channels by which the rate of domestic price inflation can be influenced by the rate of import price inflation. The first channel is through imports used as inputs in domestic production and as a substitute for domestic goods in consumption. The second is via the influence on money wage rates, which channel is described in detail by Cooper ([5] and [6]).

Our model is a variant of the wage price model used by Lipsey and Parkin [19] and in most of empirical studies on the Phillips curve (Gordon [12], Perry [25] and Phillips [27]). By explicitly taking into account the two transmissions of foreign price inflation given above, the model can be hypothesized as follows:

$$(1)\quad \dot{P} = \alpha_1 + \alpha_2 \dot{W} + \alpha_3 \dot{P}^{m} + \alpha_4 \dot{Q}, \quad \alpha_2 > 0,\ \alpha_3 > 0,\ \alpha_4 < 0$$

$$(2)\quad \dot{W} = \beta_1 + \beta_2 U^{-1} + \beta_3 \dot{P}^{e}, \quad \beta_2 > 0,\ 0 \leq \beta_3 \leq 1.0$$

$$(3)\ \dot{P}^e = \eta\dot{P} + (1-\eta)\ \dot{P}^e_{-1}, \quad 0 \leq \eta \leq 1.0$$

where $\dot{P}$ = the rate of change of consumer prices; $\dot{W}$ = the rate of change of money wage rates; $\dot{P}^m$ = the rate of change of import prices; $\dot{Q}$ = the rate of change of output; U = the percentage of the labor force unemployed; and $\dot{P}^e$ = the expected rate of changes of consumer prices; numeric subscripts denote lags.

Equation (1) hypothesizes the change in domestic consumer prices as being related to the change in a markup on unit labor cost and import prices. The level of markup over average cost of production is postulated to depend positively on the new orders relative to output levels.[2/] Adequate information is lacking on productivity and new orders. Consequently, we exclude the two variables from the specification and assume the constant term to take care of their role. Thus, the money wage rates, import prices and output levels are included. The coefficient of import prices, α_3, depends on the degree of the openness of an economy, and the lag effects of import prices are ignored because the total impact falls within one year.[3/] Equation (2) represents the standard Phillips explanation that the change in money wage rates is dependent upon changes in the reciprocal of unemployment rate and the anticipated rate of inflation. The expected rate of domestic inflation is defined in (3) as a geometric distributed lag over current and past experienced inflation rates. We assume in equation (2) the coefficient of expected prices, β_3, to be less than unity, based on empirical evidence as given in Table 1.[4/]

The model has two endogenous variables, the rates of change in domestic prices and in money wage rates, and four exogenous variables; the

Table 1 -- A Collection of the Estimated Coefficient of Price Expectation Variables, β_3, in Money Wate Rate Equations

	Coefficient	Country
Eckstein & Brimmer [9]	0.50	U.S.
Flanagan [10]	0.41-0.42	U.S.
Gordon [12]	0.35-0.47	U.S.
Hirsch [14]	0.77	U.S.
deMenil & Enzler [22]	0.57	U.S.
Perry [25]	0.34-0.49	U.S.
Turnovsky & Wachter [33]	0.42-0.49	U.S.
Flanagan [10]	0.41-0.48	U.K.
Goldstein [11]	0.51	U.K.
Lipsey & Parkin [19]	0.48	U.K.
Turnovsky [32]	0.50-0.93	Canada
Toyoda [31]	0.47	Japan
Modigliani & Tarantelli [23]	0.72-0.88	Italy
Flanagan [10]	0.8	Sweden

unemployment rate, output, import prices and lagged expected prices. We solve (1) - (3) for the rate of inflation and money wage rates. Since we are particularly interested in the price level, we write only the equation determining the rate of price inflation, leaving the wage equation in the background:

$$(4)\quad \dot{P} = \frac{1-(1-\eta)\,L}{1 - \alpha_2\,\beta_3\,\eta - (1-\eta)\,L}\quad (\alpha_1 + \alpha_2\,\beta_2\,U^{-1} + \alpha_3\,\dot{P}^m + \alpha_4\,\dot{Q})$$

where L is the lag operator, $Lx = x_{-1}$ for any x. If we further assume that the rate of anticipated inflation is exactly realized; $\dot{P} = \dot{P}^e$, then equation (4) becomes:

$$(5)\quad \dot{P} = \gamma_1 + \gamma_2\,U^{-1} + \gamma_3\,\dot{P}^m + \gamma_4\,\dot{Q}$$

The coefficient and signs derived from (1) - (3) are as follows:

$\gamma_1 = (\alpha_1 + \alpha_2\,\beta_1)\ /\ (1-\alpha_2\,\beta_3)$, $\gamma_2 = \alpha_2\,\beta_2\ /\ (1-\alpha_2\,\beta_3) > 0$, $\gamma_3 = \alpha_3\ /\ (1-\alpha_2\,\beta_3) > 0$ and $\gamma_4 = \alpha_4\ /\ (1-\alpha_2\,\beta_3) < 0$.

Equation (5) is the price equation when both prices and wage rates are simultaneously determined by the unemployment rate, the growth rate of real output and import prices. If equation (1) is the short-run price equation in the sense that the money wage rates are taken as exogeneously given, equation (5) can be interpreted as the long-run equation. $0 < \alpha_2\,\beta_3 < 1$ is met because $0 < \beta_3 < 1$, and $0 < \alpha_2 < 1$ where α_2 reflects the share of labor inputs in the total value of output (about 0.7 according to Ball and Duffey [1]). Thus, the coefficient on import prices in the long-run equation (5), γ_3, is larger by the multiplier factor $1/(1-\alpha_2\,\beta_3)$ than the coefficient in the short-run price equation (1), α_3. In other words the effect of a rise in import prices on domestic prices will be greater when money wage rates are permitted to vary in response to domestic inflation. It is also clear that an increase in import prices produces a less favorable trade-off between the unemployment rate and the rate of price inflation in the context of our model where the unemployment rate is treated exogeneously.

II. EMPIRICAL RESULTS

For an empirical test of the model, the world is divided into the United States and the non-United States. The non-United States, which may be called the foreign country, comprised the following 12 industrial countries: Austria, Belgium, Canada, Denmark, Finland, Italy, Japan, the Netherlands, Norway, Sweden, United Kingdom, and West Germany. A limited number of the countries published quarterly data, particularly on unemployment rates. Since the formation of EEC in 1959, trade among industrial nations has become freer, leading to more integrated world markets. Our empirical analysis is based on equation (5) and annual observations ([15] and [34]) for the period 1959-1971 for the reasons given above.

Prices and the unemployment rate of the non-United States are assumed to be unweighted averages of the corresponding variables for the 12 individual countries. This type of aggregation gives the same weight to each country and assumes that measures of the variables are compatible with each other. The differences in measurement are known to be great, particularly as regards unemployment rates. Thus, the empirical results based on the aggregated data are subject to an aggregation bias and the need for further refinement.[5/] Nevertheless, the empirical results are considered to be useful by showing the applicability of the model in explaining the interdependence of prices in the world and by providing estimates on the effects of external prices on domestic prices.

Table 2 contains the estimated equations for the United States and the non-United States. All the coefficients are significant at the 5% level and have the expected signs. The overall fit, measured by $\bar{R}^2$ and SEE, is reasonably good, although there is some autocorrelation in the residuals, as indicated by the DW values. The coefficients of the inverse of the U. S. unemployment rate in (6) and (7) are larger than those of the inverse of the non-U. S. unemployment rate in (8) and (9). For instance, the U. S. coefficient in (6), 0.185, is three times larger than the foreign coefficient in (8), 0.051.[6/] One possible reason for this may be a higher mobility of foreign laborers within and among occupations in response to tightness in the labor market. The difference between the two coefficients suggests that the United States incurs a higher level of inflation in order to reduce a given level of unemployment than the foreign country. That is to say, a reduction in U. S. unemployment is more costly in terms of inflation, whereas a reduction in foreign inflation is more painful in terms of unemployment rate.

Let us turn to the coefficients of the import price inflation variables. As stated above, they are significant variables. To supplement the t-test, we perform an F-test to see whether the exclusion of import price inflation variables greatly reduces the explanatory power. Equations (7) and (9) are those obtained when the coefficient of the import price variable in each equation is constrained to be zero. The F values computed from both (6) and (7) for the United States and that from (8) and (9) for the non-United States are, respectively, 5.4 and 36.0.[7/]

The critical value of F statistic with 1 and 9 degrees of freedom is 4.8 at the 5% level of significance. Hence, the rate of import price inflation variable can be regarded as an additional determinant of domestic inflation rate.

Table 2 - Regression Equations, 1959-71

$$\dot{P} = \gamma_1 + \gamma_2 U^{-1} + \gamma_3 \dot{P}^m + \gamma_4 \dot{Q}$$

	Equation Number	γ_1	γ_2	γ_3	γ_4	$\bar{R}^2$	SEE	DW
United States	(6)	-0.012 (1.06)	0.185 (3.34)	0.313 (2.65)	-0.139 (.191)	0.782	0.008	1.567
	(7)	-0.013 (0.96)	0.244 (3.78)		-0.265 (3.78)	0.650	0.010	1.349
Non-United States	(8)	0.026 (2.88)	0.051 (2.93)	0.371 (6.81)	-0.231 (3.81)	0.897	0.004	2.299
	(9)	0.021 (0.99)	0.082 (2.06)		-0.278 (1.96)	0.430	0.010	0.626

Notes: 1. Data sources are [15] and [34]. Price and industrial production indices are based on 1963=100, whereas unemployment rate is in per cent.

2. $\dot{P} = \log (P/P(-1)$, $\dot{P}^m = \log (P^m/P^m(-1))$, and $\dot{Q} = \log (Q/Q(-1))$ are used in estimation.

3. Figures in parentheses are t-statistics; $\bar{R}^2$ and DW are, respectively, the percentage of variance explained corrected for degree of freedom and the Durbin-Watson statistic. SEE stands for the standard error of the estimate.

The coefficients of the U. S. and foreign import price variables, γ_3, are estimated to be 0.31 and 0.37, respectively. The estimates are close to the estimate of Cooper ([6], p.499), 0.42, obtained by the cross-section regression for 19 countries whose currencies were devalued during the period 1959-1966. Our estimates suggest that on the average U. S. prices rise by a rate of about 0.3 point of the rise in U. S. import price inflation, when the U. S. unemployment rate and output level are taken as given. On the other hand, foreign prices increase by a rate of about 0.4 point of the increase in its import price inflation. Using information in Table 1, the multiplier factor, $1/(1-\alpha_2\beta_3)$, is as a first approximation assumed to be about 2.5. Then we derive from the estimates given above that the U. S. and foreign structural coefficients α_3 in (1), are 0.12 and 0.15, respectively. The derived structural coefficient of the U. S. import price variable, 0.12, is higher than an indicator for the openness of an economy measured by the average ratio of imports to gross national product, (about 0.066 for the United States during the sample period). As pointed out in detail by Harberger [13], the indicator excludes the effects of a change in import prices on the prices of both export-and import-type commodities produced and consumed at home, thereby resulting in the under-estimation of the openness. While our estimates are not definitive, they are not likely to be greatly out of line.[8/]

III. EXCHANGE RATE AND RELATIVE DOMESTICE PRICES

As we have found above, a rise in import prices is expected to induce a substantial increase in the domestic prices of the importing country. Further, it seems reasonable that a positive association exists between the export prices of a country and its domestic prices. In this case, what is interesting is the effects on domestic, foreign, and relative prices caused by a change in the effective exchange rate which is passed through to the prices of traded goods.[9/]

To tackle the above question with our results, one assumption needs to be added regarding the relationship between import prices and the exchange rates and domestic prices of an exporting country. Under the standard conditions of negatively-sloping demand and positively-sloping supply schedule, the rate of change in import prices in the currency units of an importing country depends positively on the price elasticities of demand and supply, the rate of change in the domestic prices of the exporting country, and the exchange rate. The exchange rate and domestic prices are regarded as factors shifting the demand and supply schedules.[10/] To avoid overcomplication of the analysis, we assume that a change in the domestic prices of the exporting country shifts the supply curve by the same degree as a change in the exchange rate. With this assumption and using the derivation of Branson([2], p.21), the relationship between import prices and the exchange rate is given:

$$(10)\quad \dot{P}_i^m = k_i(\dot{E} + \dot{P}_j),\ 0 \leq k_i = \theta_j/(\theta_j - \epsilon_i) \leq 1,$$

where $\dot{P}_i^m$ = rate of change of import prices of ith country in domestic currency units; $\dot{E}$ = rate of change of the exchange rate (units of ith domestic currency per unit of the currency of jth exporting country); $\dot{P}_j$ = rate of change of domestic prices of jth exporting country in its own currency; ϵ_i = own price elasticity of ith import demand, $\epsilon_i < 0$, and θ_j = own price elasticity of jth supply, $\theta_j > 0$. By definition, k_i lies between 0 and 1 because $0 \leq \epsilon_i \leq -\infty$ and $0 \leq \theta_j \leq \infty$.

Let d and f be the United States and the non-United States and let (10) for i, j = d, f, be introduced into the estimated equations of unemployment rates and real outputs for the sample period are expressed by

(11) $\dot{P}_d = 0.02 + 0.313\ k_d(\dot{E} + \dot{P}_f)$

(12) $\dot{P}_f = 0.03 + 0.371\ k_f(\dot{P}_d - \dot{E})$.

Now, we solve (11) and (12) to express U.S. and foreign inflations and U.S. relative price advantage, $\dot{\Pi}$, as a function of the exchange rate and two parameters, k_d and k_f:11/

$$(13)\quad \dot{P}_d = \frac{0.02 + 0.313\ k_d(1 - 0.371\ k_f)\dot{E}}{(1 - 0.116\ k_d\ k_f)},\quad \frac{\partial \dot{P}_d}{\partial k_d} > 0,\quad \frac{\partial \dot{P}_d}{\partial k_f} < 0$$

$$(14)\quad \dot{P}_f = \frac{0.03 - 0.371\ k_f(1 - 0.313\ k_d)\dot{E}}{(1 - 0.116\ k_d k_f)},\quad \frac{\partial \dot{P}_f}{\partial k_d} > 0,\quad \frac{\partial \dot{P}_f}{\partial k_f} < 0.$$

$$(15)\quad \dot{\Pi} = \frac{0.01 + (1 - 0.313\ k_d)(1 - 0.371\ k_f)\dot{E}}{(1 - 0.116\ k_d k_f)},\quad \frac{\partial \dot{\Pi}}{\partial k_d} < 0,\quad \frac{\partial \dot{\Pi}}{\partial k_f} < 0,$$

where, since the relative price advantage of the United States is the ratio of U.S. import prices over U.S. domestic prices, $\Pi = P_f E/P_d$, its rate of change, $\dot{\Pi} = \dot{P}_f + \dot{E} - \dot{P}_d$.

As expected except for the trivial case $k_d = k_f = 0$, a devaluation of the U.S. dollar against foreign currencies results in an increase in the U.S. prices which is less than the rate of devaluation. Similarly, the revaluation leads to a decrease in foreign prices less than the rate of revaluation. Accordingly, an improvement in the U.S. relative price advantage by a given level of the devaluation is less than the rate of devaluation. When the price elasticities of imports demanded are more elastic and the elasticities of imports supplied are more inelastic, k_d and k_f are smaller, thereby resulting in a larger improvement in the relative price advantage.

Given the feasible values of k_d and k_f, equations (13) - (15) indicate that the ranges of the per unit devaluation effect are

$0 \leq \dot{P}_d \leq 0.31$, $-0.37 \leq \dot{P}_f \leq 0$, and $0.49 \leq \dot{\Pi} \leq 1$. Table 2 reports the values of $\dot{\Pi}$, and the average value of $\dot{\Pi}$ computed by the frequency distribution given in the table is about 0.7. This may suggest, on the average, that a one percentage point devaluation would improve the U.S. relative price advantage by 0.7 point. If the value of k_d is assumed to be 0.8, the average $\dot{\Pi}$ implies that k_f is 0.2.[12/] In this case, a one percentage devaluation ultimately increases the U.S. prices by 0.2 point and decreases the foreign prices by 0.1 percentage point.

Table 2 -- U.S. Relative Price Change to Percentage Devaluation

$k_d \setminus k_f$	0	0.2	0.4	0.6	0.8	1.0
0	1.0	0.93	0.85	0.78	0.70	0.63
0.2	0.94	0.87	0.81	0.74	0.67	0.60
0.4	0.88	0.82	0.76	0.70	0.64	0.58
0.6	0.81	0.76	0.71	0.66	0.60	0.55
0.8	0.75	0.71	0.66	0.62	0.57	0.52
1.0	0.69	0.65	0.61	0.57	0.53	0.49

The values with $k_f = 0$ are identical to $\dot{E} - \dot{P}_d$ computed from (6), whereas the values with $k_d = 0$ are $\dot{E} + \dot{P}_f$ computed from (8).

IV. SUMMARY

This paper presents a simple model showing the dependence of domestic inflation on import price inflation. The empirical estimates for the United States and the foreign industrial countries seem to confirm the prediction of the model, especially with regard to the importance of import prices in influencing domestic prices. In addition, this paper provides a framework from which the effects on domestic prices of a change in exchange rates are computed, taking account of induced changes in money wage rates and foreign prices.

Two main empirical results emerge. First, a one percentage point increase in the rate of U.S. and foreign import price inflation results in about 0.3 point rise of the U.S. prices and 0.4 point rise of the foreign prices, respectively, holding the unemployment rate and rate of increase of output constant. These estimates include the effects of rises in money wage rates induced by the increase in import prices. The rate of domestic inflation is measured here by the prices of consumer goods. Second, a one percentage point devaluation of the dollar would raise, on the average, U.S. prices by a rate of 0.2 percentage point, and the foreign prices would be reduced by 0.1 percentage point, allowing the simultaneous interdependence of domestic prices and the exchange rate. Consequently, the change in the U.S. relative price advantage from the devaluation is estimated here to be about 70% of the rate of devaluation. This suggests that the estimates of the improvement of the U.S. trade balance due to a dollar devaluation will be over-stated, if they are made with the assumption that the rate of change of the U.S. relative price advantage equals the rate of devaluation.

Finally, the estimates and inferences are highly tentative for the reason noted earlier. The response of domestic prices to external inflation and the resultant changes in relative price advantages should be seen more clearly and accurately when equations are estimated at a finer level of aggregation in terms of country and industry.

FOOTNOTES

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1. Branson ([2], pp. 20-22) recognized this explicitly. Shields and Willett [29] discussed the proposition that currency depreciation is inflationary and listed articles contributed to the discussion on the subject.

2. de Menil ([21], pp. 3-5) and Gordon ([12], pp. 126-129) discussed in detail the determinants of markup levels. Both preferred detrended capacity output levels to actual levels of output and production.

3. Lipsey and Parkin [19] found the lag length to be one quarter, whereas Goldstein [11] found it to be three quarters. Perhaps, a one year lag could be tried when equations are fitted with annual observations.

4. If the coefficient is unity and if, in addition, actual and expected inflation are equal, i.e., $\eta = 1$ in (3), an inverse relationship between real wage rates and unemployment rates still exists. However, the relationship no longer represents the trade-off relationship between unemployment and inflation. For discussion on the subject, see Laidler [18] and Phelps [26].

5. Spitäller [30] reported that the estimated coefficients of import prices, γ_3, are 0.22 - 0.35, using annual data 1955-1969, for the four countries: Austria, Japan, Netherlands, and U.K. The estimate of non-U.S. import price coefficient reported here is about 0.37, which seems to be the same range of his estimates, considering closer linkage of prices in the world in more recent years.

6. Spitäller [30] and Flanagan [10] reported the similar conclusion.

7. The formula used in computing an F-test is $F = (N - M_o)\ (SSR_1 -$ SS SSR_o where N = the number of observations, M_o = the number of parameters to be estimated without constraints, SSR_1 = sum of squared residuals with constraints, and SSR_o = sum of squared residuals without constraints.

8. William Nordaus presented at a Federal Reserve seminar that the structural contribution of U.S. import prices to the changes in U.S. wholesale prices during the period from November 1972 to April 1973 is found to be $\alpha_3 = 0.14$, based on the input-output coefficients estimated in 1963.

9. The definition of pass-through is given by Branson ([2], p. 20), namely the degree of absorbing the change in exchange rates on foreign sales. On the other hand, Magee [20] analyzed the pass-through problem for the very short period following a devaluation. For more information, see Magee [20] and Branson [2].

10. The exchange rate change in Branson ([2], p. 21) is equivalent here to the domestic price change and exchange rate variation. The constancy of domestic prices in the currency of the exporting country leads to Branson's formula. The relationship given is the relationship which holds after shifting demand and supply schedules. We note that domestic prices are not export prices of exporting countries.

11. The impact of increases in export demand on prices are not included.

12. Branson ([2], p. 22) seems to be in favor of $k_d = 0.7 - 0.8$, whereas Clark ([4], pp. 14-15) found $k_d = 0.35 - 0.45$ for 1971-72. If $k_d = 0.8$ is first fixed and the average value of $\dot{\Pi}$ is computed on the basis of $k_d = 0.8$ line in Table 2, the average value of $\dot{\Pi}$ is 0.6 and k_f turns out to be 0.6.

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