A complete list of Working Papers
on the last pages

No. 53, 1981

Overshooting and Asymmetries in the Transmission of Foreign Price Shocks to the Swedish Economy

by
Hans Genberg *

* Graduate Institute of International Studies
Geneva, Switzerland

September, 1981

Overshooting and Asymmetries in the Transmission of Foreign Price Shocks to the Swedish Economy

I. Introduction

This paper is concerned with the relationship between an exogenous foreign price shock and the subsequent (and consequent) movement in the domestic price level. The reason for approaching this topic again, given the existing abundant literature, was a desire to investigate empirically three hypotheses suggested recently by simulations of a model of the Swedish economy[1]. Specifically, (1) does the Swedish price level adjust smoothly to a foreign price shock or does it overshoot and oscillate?, (2) does the size of the foreign price shock matter for the speed of the adjustment process?, and (3) does the domestic pice level react differently to a foreign price increase than to a foreign price decrease? These questions are addressed here using a modified version of a price equation commonly used in studies of the transmission of inflation and data on Swedish consumer prices and import prices for the period 1947 to 1979.

The next section discusses the price equation which will be used and takes up some theoretical arguments concerning overshooting and asymmetries of adjustment. In section III the empirical results are presented, evaluated and compared to those of the simulation model refered to above. In the final section the principal limitations of the study are taken up together with suggestions for extensions.

---

1 See Gunnar Eliasson "How Does Inflation Affect Growth? - Experiments on the Swedish Micro-to-Macro Model", in Micro-Simulation Models, Methods and Applications (B. Bergmann, G. Eliasson, G. Orcutt, eds.), Stockholm: The Industrial Institute for Economic and Social Research, 1980.

II. Theoretical Considerations

The domestic price equation

A common formulation of an equation determining the domestic rate of inflation in a small open economy with a fixed exchange rate is

$$\Pi_t = a_0 + a_1\Pi_t^* + a_2 E_{t-1}\Pi_t + a_3 Z_t . \qquad (1)$$

where

Π_t = the domestic rate of inflation

Π_t^* = the foreign rate of inflation (measured for instance by the rate of change in import prices)

$E_{t-1}x_t$ = the expectation formed at time t-1 of the value of the variabled X at time t.

Z_t = a vector of variables capturing the effects of domestic and foreign monetary and fiscal policies.

Special cases of equation (1) have been proposed and estimated in the litterature. The parameter a_2 has, for instance, been assumed to equal zero in which case the domestic rate of inflation is determined solely by the actual rate of foreign inflation (maybe with a distributed lag effect) and monetary and fiscal policies[1]. It is also possible to assume that $a_1 = 0$ and that the expected rate of inflation depends on the expected foreign rate of inflation. In that case the domestic rate of inflation will be determined by the expected foreign inflation rate in addition to policy variables[2].

---

[1] See, for instance, Calmfors, Lars, 1977, Swedish inflation and international price influences, in: L. Krause and W. Salant, eds., Worldwide inflation: Theory and recent experience (The Brookings Institution, Washington, D.C.).

[2] See Laidler, David, 1976, Inflation - Alternative explanations and policies: Tests on data drawn from six countries. in: Karl Brunner and Allan Meltzer, eds., Institutions policies and economic performance, Carnegie-Rochester Conference Series on Public Policy, Vol. 4 (North-Holland, Amsterdam) 251-306.

It can be argued that both of the above special cases represent misspecification of a more general model where the foreign influence on the domestic rate of inflation comes from both expected and unexpected foreign price shocks but with different coefficients and lag structures. In line with well-known Phillips curve analysis expected inflation should influence domestic price-setting behavior directly and with a unit coefficient. Expected inflation may in turn be a function of expected foreign inflation. Unexpected foreign inflation influences domestic prices either by a direct arbitrage mechanism or by more indirect influences on demands and supplies of traded and non-traded goods. This indirect influence is likely to operate more slowly than the expectations-based one, and hence the coefficient, and the distributed lag, attached to the unexpected part of foreign inflation will be different from the unitary coefficient on the expected part. Thus we can write

$$\Pi_t = E_{t-1}\Pi_t + \Phi(L)[\Pi_t^* - E_{t-1}\Pi_t^*] + f(Z_t) \qquad (2)$$

where $\Phi(L)$ is a polynomial in the lag operator L which in turn is defined by $Lx_1 = x_{t-1}$

In order to illustrate how the implications of equation (2) differ from those of a model in which foreign disturbances affect domestic inflation only via actual values of Π^* , consider the following two examples. In both cases assume that foreign inflation increases from 5 % to 10 % per annum but in case one the increase was expected to occur, whereas in case two it was totally unexpected. In the model where only actual values of the foreign inflation rate mattered, there would be no difference between the two cases. In the model summarized by (2), however, case one would inply an immediate increase in domestic inflation from 5 % to 10 %, whereas case two would imply a slower upward adjustment in the inflation rate. Econometric analysis and policy analysis which do not take into account the distinction between expected and unexpected foreign price shocks will treat the two as equivalent and lead to erroneous coefficient estimates and conclusions.

Overshooting

In his simulations of the effects of unexpected export-price shocks on the Swedish consumer price index Eliasson (op. cit.) found that the adjustment path involved oscillations of the CPI around its new equilibrium path. He thus observed periods when the domestic price level overshot the long run equilibrium level implied by the price increase of exports. Such overshooting may have undesirable consequences for resource allocation and relative profitability of domestic industrial sectors. Hence it is of interest to find out if it is an empirically verifiable feature of the Swedish economy.

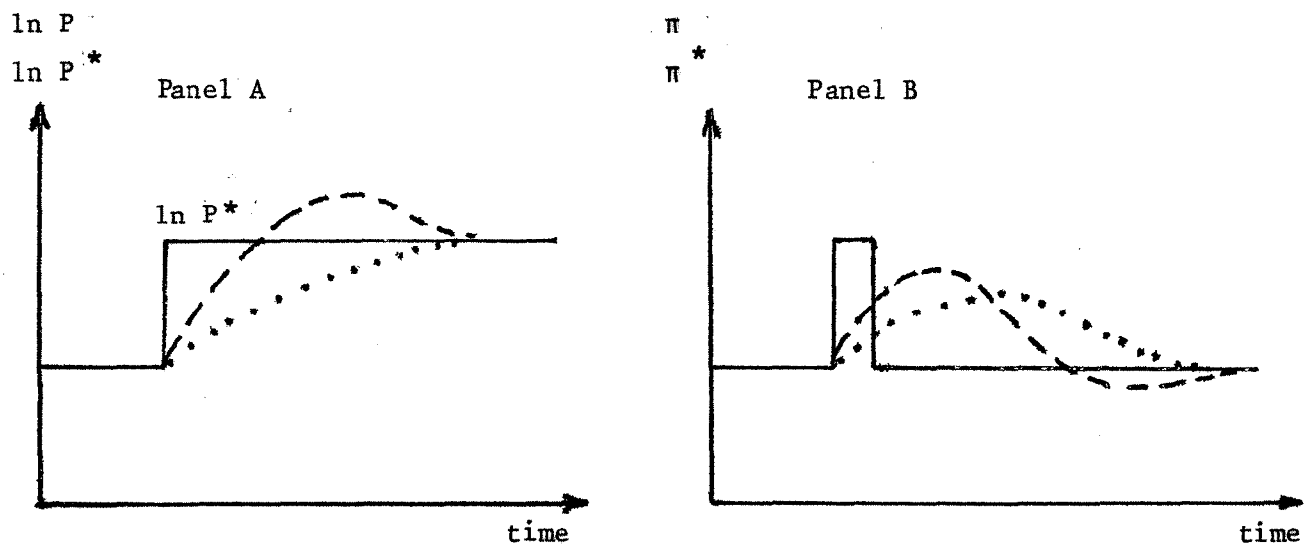
Two different kinds of overshooting should be distinguished; overshooting of the price level and overshooting of the inflation rate. If we are willing to assume that in full equilibrium the relative price of imports to domestic goods should return to its initial level[1] then, as a matter of pure arithmetic, it follows that the domestic rate of inflation must necessarily overshoot the foreign rate (except in a very special case mentioned below) whereas the domestic price level need not do so.

Consider Figure 1. It depicts a once-and-for-all change in the price of imports. In panel A two possible paths of the domestic price level are shown. Both converge on the new price of imports

---

1 This is indeed what one should expect to happen in the case where the foreign price shock is the result of pure foreign inflation and not of a real change such as a change in the terms of trade.

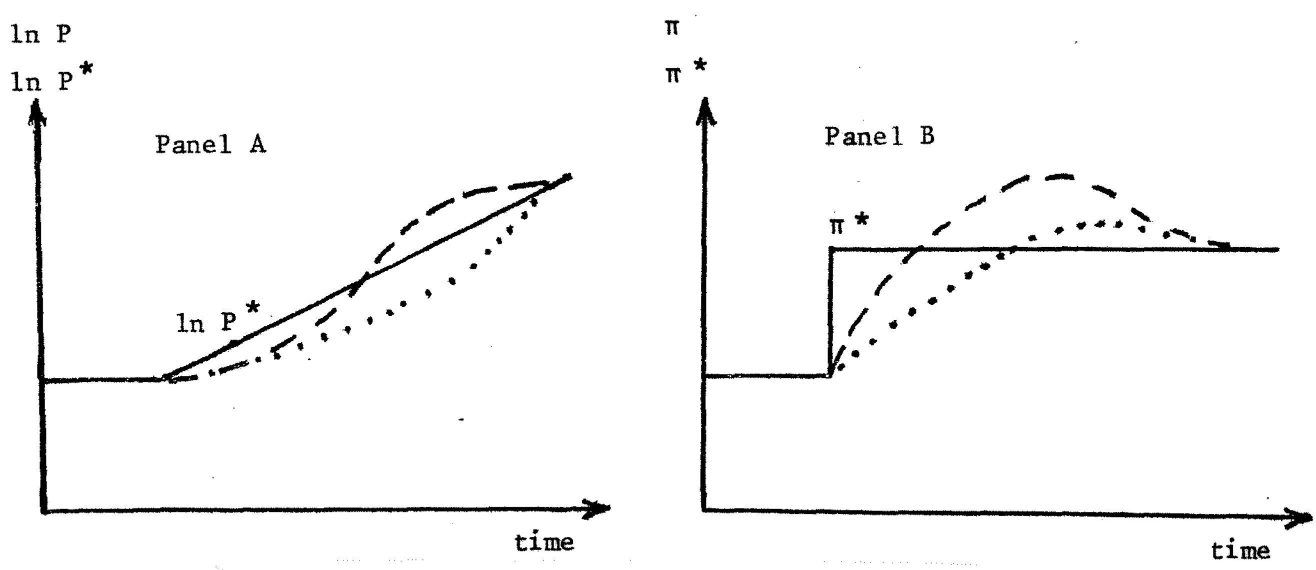
Figure 1.



as they must if the relative price is to return to the initial level. The dotted path represents a monotonic convergence and the dashed parh an oscillatory one involving overshooting. In panel B the rates of change of prices are shown for the same price shock. Unless π reacts fully and immediately to π^* there must be some period of time where π is higher than π^* during the adjustment process.

Figure 2 shows the adjustment path to a once and for all increase in the foreign rate of inflation. Again, panel A indicates that the domestic price level may or may not overshoot, and panel B shows that the inflation rate necessarily does. To repeat, this overshooting of the inflation rate follows automatically from the

Figure 2.



assumption that relative prices will ultimately return to their initial level and that the domestic price adjustment is not instantaneous.

Asymetric adjustments

The proposition that the adjustment process to price shocks is different for price increases than for price decreases and for large as opposed to small price changes has often been stated. As applied to price increases versus price decreases the argument is usually that many prices and wages are sticky in the downward direction and that one should therefore expect a longer adjustment path for a negative price shock than for a positive one.

A theoretical argument for a differential effect of large versus small price shocks can be built on the idea that there are costs attached to altering prices, and that these costs increase with the speed with which the adjustment is carried out. The adjustment costs may be associated with changing price lists and informing retailers about these changes. They can also be due to loss of goodwill among customers if changes of prices take place too frequently.

Facing such costs the rational firm which has some short-run power to set its price will weigh the present value of the benefits from changing the price with the present value of the adjustment costs. If the former is greater the firm will decide to adjust its price. If the adjustment cost is fixed and independent of the size of the change and of the speed with which the change occurs then the above argument implies that the firm will either adjust or not, but if it has decided to adjust it will do so immediately. Since the present value of the benefits of adjusting depends positivly on the size of the foreign price shock, the larger the shock the more likely it is that firms will adjust, but there is no reason to believe that they will do so slowly. In order to establish this kind of behavior it is necessary to assume that the cost to the firm of changing its price depends on the speed at which it does it. In this case it follows that a larger foreign price shock would lead to quicker adjustment than a smaller one.

III. Preliminary empirical analysis

In a preliminary attempt to estimate the parameters in equation (2) some simplifying assumptions had to be made concerning the influence of policy variables, the formation of expectations, and the lag structure implicit in the Φ (L) function. As a first step the policy variables denoted by z in (2) were left out completely. Expectations concerning the rate of increase in foreign prices were assumed to be formed according to the adaptive, error-learning, process defined by

$$E_{t-1}\Pi^*_t = \frac{\alpha}{1-(1-\alpha)L} \Pi^*_{t-1} \tag{3}$$

The expected rate of domestic inflation was assumed to be made up of two components; on the one hand an adaptive process similar to that in (3) and on the other hand a distributed lag function of the relative price of domestic to foreign goods. The latter variable was included with the idea that an increase in the relative price of domestic goods would lead economic agents to expect the domestic rate of inflation to slow down somewhat because of shifts in demand away from domestic goods. The two components of the expected rate of inflation are combined in (4)

$$E_{t-1}\Pi_t = \frac{\alpha}{1-(1-\alpha)L}\Pi_{t-1} + \beta\Phi(L)\ RELP_{t-1} \tag{4}$$

The definition of the relative price variable was

$$RELP_t = \ln p_t - \hat{a}_0 - \hat{a}_1 \ln p_t^* - \hat{a}_2 t$$

where the estimates of the a:s were obtained by regressing the logarithm of the domestic price level, p, on the logarithm of the foreign price index, p^*, and a time trend[1]. Note also that the error learning coefficient α is assumed to be the same in (3) and (4) and that the distrubuted lag function on the relative price variable is the same as that on unexpected foreign inflation in (2) up to a multiplicative constant β. On the argument given above concerning the effect of relative prices, β should be negative. Combining (2), (3) and (4) and defining

$y_t = \Pi_{t-1} - \Pi_t$ and $x_t = \Pi_t^* - \Pi_{t-1}^*$ yields (5).

$$y_t = \Phi(L)x_t + \beta[1-(1-\alpha)L]\ \Phi(L)RELP_{t-1} \tag{5}$$

Attempts were made to estimate the lag function in equation (5) both freely without restrictions and with the Almon-lag technique. The former failed in the sense that the coefficients on the individual lagged variables were very poorly determined probably due to the relatively large number of parameters involved compared to the number of observations. The Almon-lag procedure, although it did produce coefficient estimates of correct size and

---

1 The sample period was 1947 to 1979, p was the Swedish consumer price index adjusted for indirect tax changes, and p^* was the import price index. The result of the regression was

$$\underset{}{\ln p_t} = \underset{(24.6)}{2.54} + \underset{(14.6)}{0.423}\ \ln p_t + \underset{(28.10)}{0.30t}$$

$R^2 = .19$, D-W = .33, (t-values in parenthesis).

plausible values, was abandoned because it proved to beather cumbersome when it came to testing for the presence of asymmetries in the adjustment process. The lag pattern finally settled on assumed that the lag distribution took the form

$$\Phi(L) = \frac{1 - b_1 - b_2}{1 - b_1 L - b_2 L^2} \tag{6}$$

It can be shown that this formulation is equivalent to the infinite series

$$\Phi(L) = (1-b_1-b_2) \sum_{i=0}^{\infty} d_i L^i$$

where

$d_o = 1$

$d_1 = b_1$

$d_{i-1} = d_1\, d_{i-1} + b_2\, d_{i-2}$ for $i \geq 2$.

The function defined by (6) allows for a quite flexible lag structure while, at the same time, it is relatively simple to estimate since it involves only two parameters. Note also that (6) implies that the sum of the lag coefficients is equal to unity ensuring full transmission of foreign inflation in the long run.

Combining (5) and (6) gives

$$y_t = b_1 y_{t-1} + b_2 y_{t-2} + (1-b_1-b_2)x_t + \beta(1-b_1-b_2)\,[1-(1-\alpha)L]\,\mathrm{RELP}_{t-1}$$

which in turn can be rearranged to read

$$y_t - x_t = b_1(y_{t-1}-x_t) + b_2(y_{t-2}-x_2) - c_1\mathrm{RELP}_{t-1} + + c_1(1-\alpha)\mathrm{RELP}_{t-2} \tag{7}$$

where $c_1 = -\beta(1-b_1-b_2$,.

Equation (7) is the form which was confronted with the data[1]. The results for the whole sample period 1951-1979 and three subperiods are presented in Table 1.

---

[1] The raw data were observations on the Swedish consumer price index adjusted for indirect tax changes and on the Swedish import price index for the period 1947-1979. Data sources: The Swedish Economy, Stockholm; Konjunkturinstitutet, various issues.

Table 1

$$y_t - x_t = b_0 + b_1(y_{t-1}-x_t) + b_2(y_{t-2}-x_2) +$$

$$+ b_3 \text{ RELP}_{t-1} + b_4 \text{ RELP}_{t-2}$$

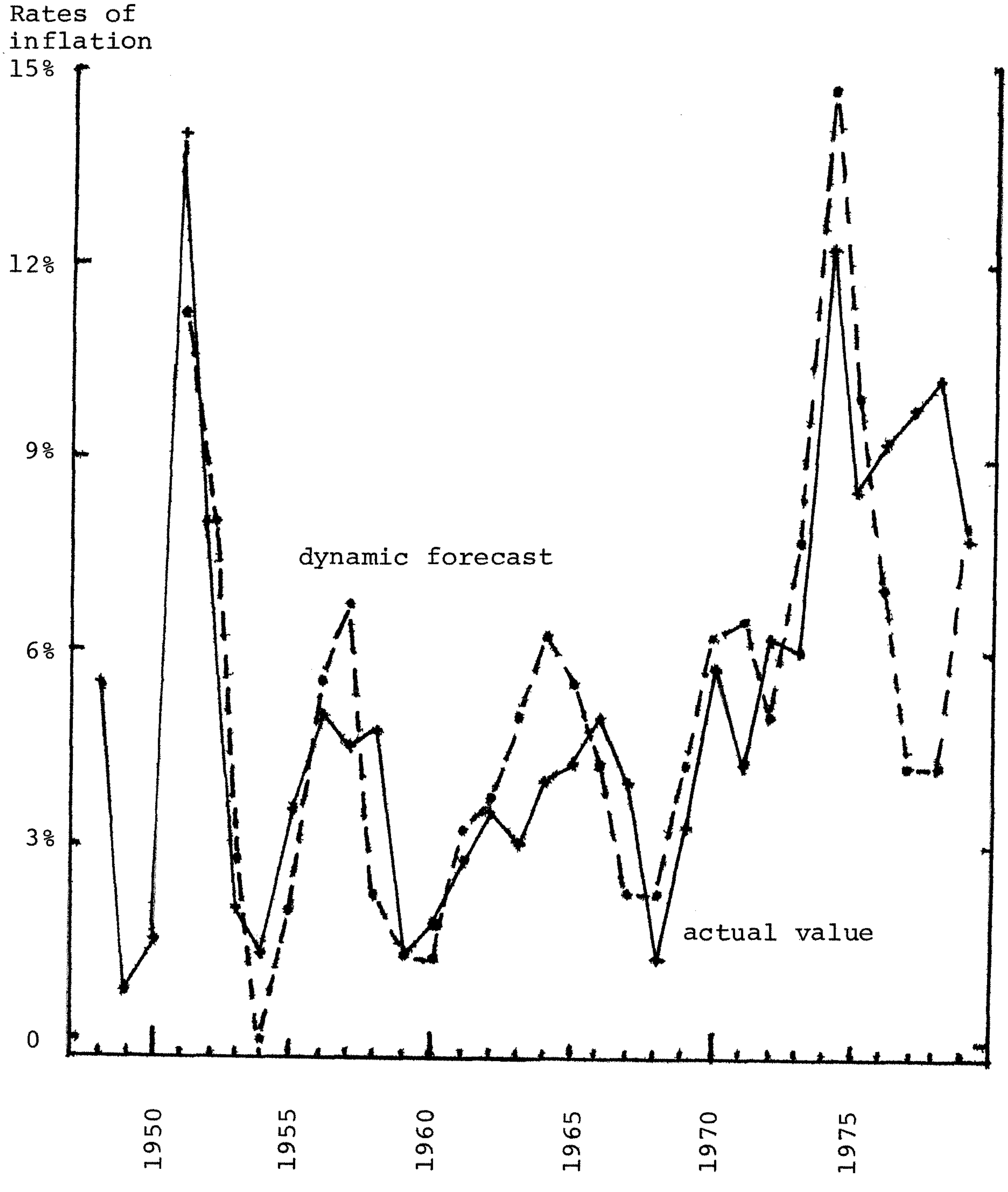
Sample period	b_0	b_1	b_2	b_3	b_4	R^2	D·W
1951-1979	.0018 (.45)	.3078 (3.96)	.3530 (4.06)	-1.0260 (-6.58)	.9135 (5.34)	.94	1.81
1951-1965	.0062 (1.09)	.2681 (2.98)	.3270 (3.26)	-1.2134 (-6.02)	.8955 (3.89)	.95	2.25
1956-1972	-.0025 (-.58)	.3636 (2.71)	.4821 (3.04)	-.9092 (-3.91)	.9659 (4.26)	.92	2.49
1966-1979	-.0026 (-.35)	.3037 (1.99)	.4329 (2.44)	-.7090 (-2.70)	.5670 (1.78)	.94	2.23

The first thing to notice in this table is that all coefficients[1] have the expected sign and are highly significant especially for the full sample period. b_1 and b_2 both lie in the interval zero to one which the theory predicted. b_3 is negative and b_4 positive as the discussion around the effect of the relative price term implied. The estimate of the error-learning parameter α in the adaptive expectations formulae also takes on a plausible value. From (7) it can be seen that $\alpha = 1 + {}^{b_4} / {}_{b}3$ which, given the parameter estimates of the first row of Table 1, implies $\hat{\alpha} = .11$. The goodness of fit of the equation is satisfactory and, again for the full sample in particular, there is no sign of any serial correlation in the residuals. In order to check the ability of the model to track the rate of inflation π , the estimates in the first row of the table were used to calculate a predicted inflation rate. The correlation coefficient between that predicted rate and the actual inflation rate was .86. Figure 3 presents another measure of the model's ability to track the actual

---

[1] The exception is the constant b_o for which there were no strong prior expectations concerning sign and size any way.

Figure 3. Actual values and dynamic forecasts of the domestic rate of inflation



inflation rate during the sample period. The dashed line represents the model's dynamic ex post forecast of the rate of inflation. That is the forecast based on the actual movement of the import price index during the whole sample and the actual value of the consumer price index for the period 1947 to 1950. From 1951 onwards, the model uses its own forecasts of Π_t when it calculates Π_{t+i} . Hence it represents a better test of the dynamic structure of the model than the correlation coefficient between the actual and fitted values of the regression itself. As can be seen from the figure, the model again does quite well in tracking the actual inflation rate (solid line)[1]. The only notable exception is 1977 and 1978 when the model significantly underpredicts.

---

1 The correlation coefficient between the actual and predicted series is .81.

Returning to the results in table 1 it appears that the coefficients on the independent variables vary with the sample period. Several reasons may be behind this. One possibility is that the simple expectations schemes lying behind the formulation of the estimated equations are inadequate and that more sophisticated mechanisms are necessary. This will be emphasized again in the last section of the paper. Another possibility is that the size of the price shock influences the speed of adjustment. In fact, the splits of the sample were determined by the criterion that the first and third subperiods would be ones with relatively large foreign price shocks and the middle subperiod one with relatively small ones. Without pretending that the periods actually chosen are free of objection, it appears from these results that larger price shocks result in more rapid adjustment as measured by the shape of the Φ (L) function in (2)[1]. Using the estimates of b_1 and b_2 to calculate the lag structure according to the formulae just below equation (6) it turned out that the cumulative effect after five years of a unit disturbance was .82 for the first subperiod, .45 for the second, and .65 for the third. These estimates, as fas as they go, thus support the theoretical argument presented above.

To test for the influence of the size of the price shock more formally, the following modification to equation (7) was introduced. It was hypothesized that the coefficients b_1 and b_2 were funcions of both the size and sign of the foreign price shock[2]. Based on a need to limit the number of coefficients to be estimated and on some preliminary tests the functions defining b_1 and

---

[1] This is not an entirely unobjective measure since the relative price variable will be affected by differences in the speeds of adjustment and will in turn influence the overall adjustment process.

[2] Two measures of the price shock were tried, Π_t^* and $(\Pi_t^*-\Pi_{t-1}^*)$. The former gave uniformly more satisfactory statistical results.

b_2 were chosen so that the sum of b_1 and b_2 was unaffected by the size or sign of the shock. The specific functional form was

$$\left.\begin{aligned} b_1 &= b_1^0 + b_1^1 \left|\Pi_t^*\right| + b_1^2 D_t \\ b_2 &= b_2^0 - b_1^1 \left|\Pi_t^*\right| - b_1^2 D_t \end{aligned}\right\} \qquad (8)$$

where $|\pi_t^*|$ indicates the absolute value of π_t^* and where

$$D_t = \begin{cases} 1 \text{ if } \Pi^*_t < 0 \\ 0 \text{ if } \Pi^*_t \geq 0 \end{cases}$$

With these modifications the equation which was fitted to the data took the form

$$y_t - x_t = b_0 + b_1^0 (y_{t-1}-x_t) + b_2^0 (y_{t-2}-x_t) +$$

$$+ b_1^1 (y_{t-1}-y_{t-2}) \left|\Pi_t^*\right| + b_1^2 (y_{t-1}-y_{t-2}) D_t -$$

$$- c_1 \text{ RELP}_{t-1} + c_1(1-\alpha) \text{ RELP}_{t-2} \qquad (9)$$

where, as before, $c_1 = -\beta(1-b_1^0-b_2^0)$. According to the theory that the price adjustment to the price adjustment is faster for large compared to small and for positive compared to negative price shocks, the estimate of $b_1{}^1$ should be positive and that $b_1{}^2$ negative. The result of ordinary least squares estimation for the full sample period was

$$y_t - x_t = \underset{(.45)}{.0018} + \underset{(1.14)}{.1811} (y_{t-1} - x_t) +$$

$$+ \underset{(2.91)}{.5073} (y_{t-2}-x_t) + \underset{(1.77)}{2.60} (y_{t-1}-y_{t-2}) \left|\Pi^*_t\right| -$$

$$- \underset{(-1.02)}{.1478} (y_{t-1} - y_{t-2}) D_t - \underset{(-5.93)}{.9379} \text{ RELP}_{t-1} +$$

$$+ \underset{(4.86)}{.8334} \text{ RELP}_{t-2}$$

$R^2 = .95$, D-W $= 2.07$, (t-values in parentheses).

As before, all the coefficients have the expected sign but this time the significance level of some of them is rather low, especially that on the variable capturing the effects of the sign of the price shock. The size-coefficient is significant at the 90 % level, however, lending some support to the idea of an asymetric adjustment process.

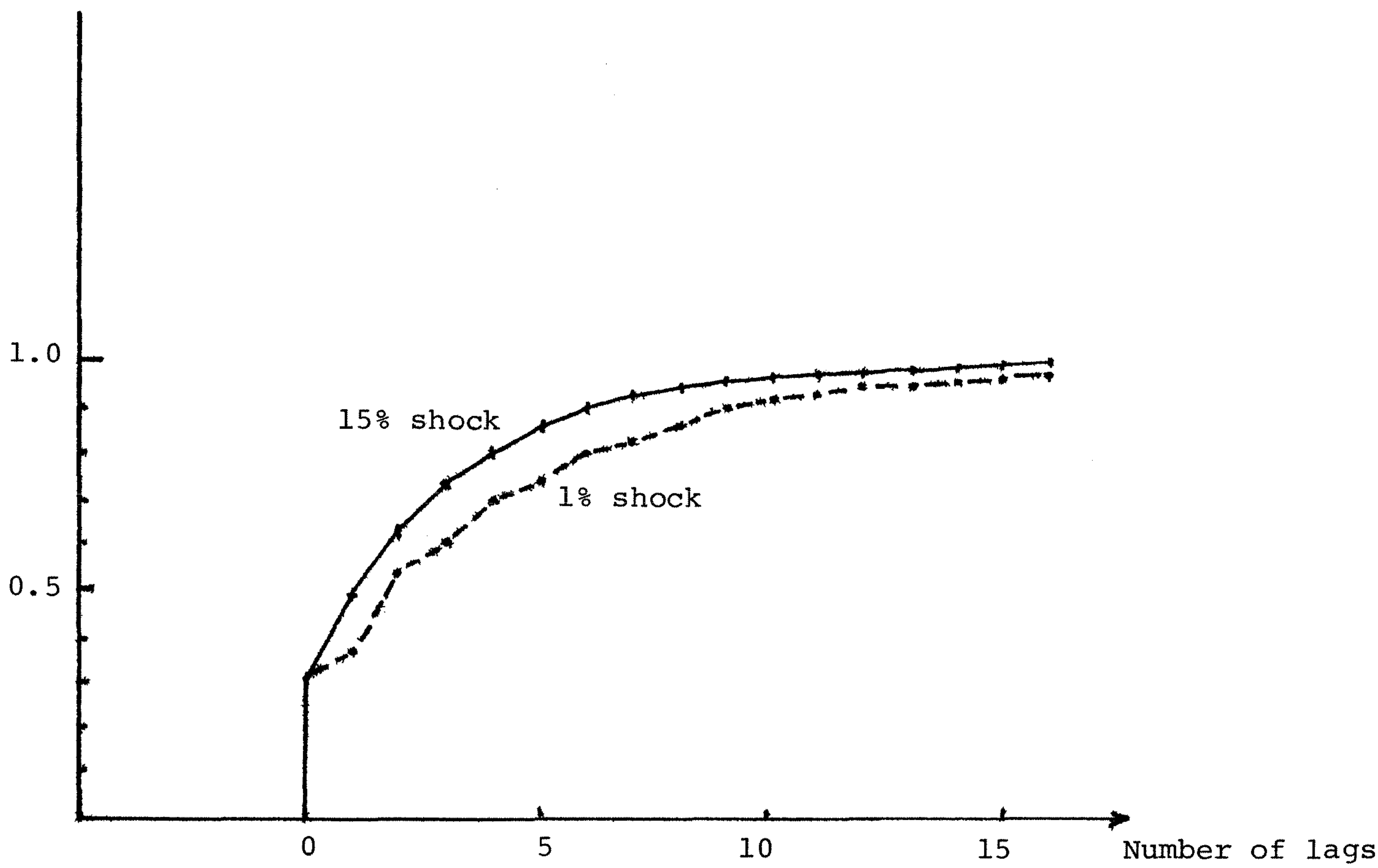
Taking the above point estimates at facevalue Figures 4 and 5 illustrate the differences that the size of the price shock makes for the adjustment path. Figure 4 shows the cumulated weights of the ϕ (L) function calculated as before, whereas Figure 5 takes into account also the feedback through the relative price variable. Figure 5 thus shows the complete adjustment path following a price shock in period 5[1]. A number of observations are prompted by these figures. Beginning with the weights in the ϕ (L) function (Fig. 4) it is clear that the distribution associated with the larger price shock (the solid line) indicates a faster response than the one associated with the smaller price shock[2]. Again, this is what the theory in section II suggested. Secondly it is noteworthy that the lag distrubutions in Fig. 3 show a smooth convergence towards the long-run value of unity indicating that any overshooting in the adjustment process must be due to feedbacks through changes in relative prices. This is confirmed in Figure 5 which captures the full adjustment process including this feedback. Here a marked tendency for domestic prices to increase above the long run equilibrium is shown. What seems to be happening, therefore, is that the initial shock increases the relative price of imports which in turn sets up forces that drive the domestic price level above its long run value even though the adjustment path indicated by ϕ (L) is monotonic.

Concerning the difference between the adjustment process for large and small shocks, Figure 5 confirms the conclusion from Figure 4 that adjustment is faster the larger the price shock. But another feature is also evident. The larger price shock also leads

1 The paths are normalized on the size of the foreign price shock.

2 The weights are calculated for a price shock of 15% and 1% respectively.

Figure 4. Cumulative weights in the $\phi(L)$ function



to wider (less damped) oscillations around the long run value. This suggests that even though agents react faster to a larger shock, their reactions to changes in relative prices lead to relatively larger fluctuations in the domestic price level[1]. This conclusion is intuitively appealing. Larger shocks create more noise in the system which should lead to larger swings in relative prices.

Finally, comparing the adjustment patterns in Figure 5 with those obtained by Eliasson shows that the overshooting property of his simulation model does seem to exist also in actual post-war data on import and consumer prices in Sweden. The oscillations are very much larger (I would argue that they are too large) in Eliasson's model than in the present one. Furthermore, the effect of the size of the disturbance is the opposite there than here. A possible reason for this might be that Eliasson uses export prices as a measure of the foreign price variable instead of import prices used in this study. This remains a conjecture, however, and should be investigated further both theoretically and empirically.

In summary, it appears from the present study that the transmission of price changes from import prices to domestic prices in Sweden's post-war experience has involved both overshooting and asymmetric response to large vs. small foreign price shocks. The asymmetry hypothesis applied to the sign of the price shock was rejected on standard statistical confidence grounds.

Extensions

At a theoretical level an important extension of the present paper would be to consider alternative hypotheses concerning the formation of expectations. Of particular interest might be the rational expectations hypothesis which would undoubtedly imply that in forming expectations about next years rate of inflation, agents look not only at current and past domestic policy and rates of inflation but also at the current and past rates of foreign inflation.

[1] Note the word "relatively". What is being described is not the absolute variation around the long-run value since the figures have been normalized to a unit shock.

Another challenge for theory would be to work out in more detail a rationale for the empirical finding (if it stands up to further scrutiny) that the size and, to some limited extent, the sign of the foreign price shock alters the transmission process.

At an empirical level the most obvious shortcomings of the present paper are, on the one hand, the exclusion of domestic policy variables from the regression and, on the other hand, the fact that the relevance of the distinction between expected and unexpected price shocks has not been determined empirically. This remains to be done in future work.