ESTIMATING THE INFLATIONARY EFFECTS OF DEPRECIATION

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ABSTRACT

This paper adopts a simple econometric approach to estimate the effects of exchange rate changes on the rate of inflation in Australia. It uses a mark-up model of price determination, in which output costs are determined by input prices. The analysis suggests that imported cost pressures have been more important in the 1980s than in the 1970s. This may be attributable to increasing openness of the Australian economy over this period. In addition, an analysis of import prices finds no evidence of "absorption" by foreign suppliers, and suggests that Australian import prices could have fallen in 1986 if not for the depreciation. This finding is attributable to the falls in the world prices of tradeable goods in 1985 and 1986. Finally, a counterfactual simulation of the estimated equations suggests that the total price effects of the 1985 and 1986 depreciations have been considerably larger than commonly argued.

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ESTIMATING THE INFLATIONARY EFFECTS OF DEPRECIATION

By Tony Richards and Glenn Stevens

1. Introduction

In the two years following December 1984, the Australian dollar depreciated by around 34 per cent against the trade-weighted index, and by around 23 per cent against the U.S. dollar. When the exchange rate is expressed in terms of units of domestic currency per unit of foreign currency the depreciation is larger - around 51 per cent on a TWI basis and around 30 per cent against the U.S. dollar. Such a large depreciation in a relatively short period provides further experience to sharpen estimates of the effect of exchange rate changes upon the domestic price level.

The Australian Statistician has estimated the effect on the Consumer Price Index of changes in the prices of wholly or predominantly imported goods. For the two years to December 1986, these effects came to 2.6 percentage points. In addition, the Commonwealth Treasury has estimated the effect of the depreciation on the prices of petroleum products at around 1 percentage point over the same period. But these effects are not the total effects of the depreciation. Rather, they are measures of the direct effect, mostly reflecting the weight of certain imports, and petrol, in the Consumer Price Index.[1]

This paper adopts a simple econometric approach to estimating both the "direct" and "indirect" effects of exchange rate changes. It uses a "mark-up" model of price determination, in which output prices are determined by input costs. Most previous Australian studies have concentrated on labour costs, proceeding then to specify equations for wage inflation, and ending by addressing questions such as the existence or otherwise of a short or long-run trade-off between unemployment and inflation.[2] Our aims, however, are simply to investigate the extent and the timing by which increases in input costs, and import prices in particular, are reflected in the prices of final goods and services.

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1. For a further discussion on these points see the Commonwealth Government's Submission to the September 1985 National Wage Case, and Treasury Round-Up, November 1985. For the March and June quarters of 1987 the Statistician has estimated the effects of increases in the prices of wholly or predominantly imported goods and services at a further 0.64 percentage points.

2. Previous work in this area includes Parkin (1973), Jonson, Mahar and Thompson (1974), Nevile (1977) and Carmichael and Broadbent (1980).

A fact which is not often appreciated in discussions of the recent depreciation is that, exchange rate influences aside, the export prices of Australia's major suppliers actually fell over the year and a half to the end of 1986. This means that the effect of the depreciation on import prices is larger than the actual increases in import prices would suggest.

Section 2 of the paper outlines the data, and introduces a measure of the export prices of Australia's major suppliers which suggests that world prices actually fell through much of 1985 and 1986. Section 3 presents the model of price determination. The model is estimated in Section 4, with equations for both domestic prices and import prices. Section 5 presents some counterfactual simulations which suggest that the effect of the depreciation upon domestic prices has been considerably more substantial than is commonly argued.

A general caveat is in order. While a study such as this can expect to go beyond the so-called "direct effects" of depreciation, it cannot measure accurately all the direct and indirect "full-system" effects. These cannot be determined without reference to a host of other factors which impinge on prices in ways not adequately captured by a single equation. For an early attempt to capture the full-system effects of depreciation for Australia, see Jonson (1973).

2. Data

There are three key data requirements for the model used in the paper:

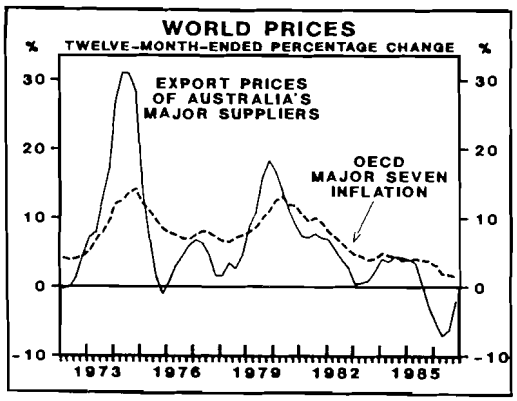
- a measure of world prices that is relevant to the determination of Australian import prices;
- a measure of import prices, measured in Australian currency; and
- a measure of unit labour costs.

For the first of these, an index of export prices is constructed for those countries which provide a significant proportion of Australia's non-oil imports. Weights are based on average shares in Australia's

imports in the six-year period to 1985/86. The 16 included countries accounted for 83 per cent of total imports in 1985/86.[3]

Movements in the world price variable are shown in Figure 1. Short-term movements in this index have been markedly at variance with those in more commonly-used indexes, such as the OECD area Consumer Price Index (also shown in Figure 1). While consumer price inflation in the major OECD economies slowed from mid-1985 but remained positive, this world price index actually declined between mid-1985 and end-1986. This suggests that, had there been no depreciation of the $A, prices of imports into Australia could well have fallen in 1986[4].

Figure 1



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3. The 16 countries (in order of importance) are the United States, Japan, the United Kingdom, West Germany, New Zealand, Taiwan, Italy, Singapore, Canada, Hong Kong, France, Indonesia, Sweden, South Korea, Switzerland and Malaysia. Two countries, Saudi Arabia and Kuwait, which might have been included on the basis of their share in total imports, were excluded because the majority of those imports were petroleum-related.

4. A similar trend emerges from OECD producer prices which also fell in this period, though not to the extent of the export price variable. Preliminary regressions using a producer price variable show very similar resuts to the preferred import price equation presented below. Both these variables provide a considerably superior explanation to a CPI variable.

The import-price variable is the implicit price deflator for endogenous imports from the National Accounts.[5] The deflator measures import prices on an f.o.b. basis. For the purposes of the CPI equation the deflator is multiplied by an average customs and tariff rate derived from the National Accounts, so as to give a better measure of the price that end-users of imported goods actually face.

The measure of unit labour costs is built up using data on average earnings on a National Accounts basis. This seems preferable to the survey-based measure of Average Weekly Earnings because the relevant measure according to the mark-up hypothesis should be one which regards wages as a cost rather than as an income. The National Accounts measure - wages, salaries and supplements - includes a number of "on-costs" such as superannuation contributions by employers, holiday pay and leave loadings. Furthermore, to reflect another on-cost, the earnings measure is adjusted using an average payroll-tax rate derived from the National Accounts.

The trend growth rate of productivity is subtracted from average earnings, to obtain a measure of unit labour costs. The appropriate measure of productivity is an hours-worked measure (around 0.5 per cent per quarter) rather than a per-employee measure (around 0.4 per cent per quarter). This yields a series for unit labour costs with productivity smoothed, and adjusted for payroll tax.[6]

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5. Endogenous imports are defined as all imported goods excluding petroleum, civil aircraft and certain large items of government expenditure, largely defence equipment. Unlike the Import Price Index (also published by the ABS), the implicit price deflator will not provide a measure of the pure price change and can be clouded by compositional change. The choice of this measure was based on the longer run of data that was available, and the fact that the import price index is a major input into the estimation of the implicit price deflator in all but the most recent quarter. Data for this and all other National Accounts variables are taken from the March 1987 Quarterly Estimates.

6. Alternative regressions were conducted using measures of changes in actual productivity rather than the trend change in productivity. The problem with using changes in actual productivity is the amount of "noise" introduced from quarter-to-quarter movements in non-farm GDP. Even when this was smoothed somewhat, the measure gave considerably worse results in terms of goodness-of-fit. In terms of $\bar{R}^2$ the best result appears to come from the assumption that productivity changes occur uniformly over time.

3. The Model of Price Determination

(a) Domestic Prices

A commonly-used approach in many studies of inflation is the mark-up model in which price movements simply reflect movements in costs. The approach has the advantage of simplicity in estimation and interpretation.

The mark-up model is obtained as follows. Let the aggregate price of consumer goods (PC_d) be a weighted average of the prices of domestically-produced consumer goods (P_d) and the price in domestic currency of foreign-produced consumer goods (P_f).

$$PC_d = (1-\delta)P_d + \delta P_f$$

P_d can be thought of as a mark-up on costs of production. Let the production function for domestic consumer goods be represented by

$$Y = F(K,L,E)$$

where K and L represent capital and labour, respectively, and E represents energy input, along the lines proposed by Helliwell et al. (1982). If F is homogeneous of degree one, then competitive equilibrium requires that

$$P_dY = WL + RK + P_EE$$

where W is the wage rate, R the rental cost per unit of capital and P_E the price per unit of energy.

This then implies that the unit price is the sum of the unit costs for labour, capital and energy. That is

$$P_d = \frac{WL}{Y} + \frac{RK}{Y} + \frac{P_EE}{Y}$$

If several simplifying assumptions are made, as is shown in Appendix 1, the following estimating equation is obtained:

$$P_{d_t} = a + \sum_{i=0}^{\ell} b_i (w_{t-i} - z) + \sum_{i=0}^{m} c_i P_{e_{t-i}}$$

$$+ \sum_{i=0}^{n} d_i p_{m_{t-i}} + eD_t + \varepsilon_t \qquad (1)$$

where P_d is the domestic price index, w is average earnings, z the trend growth in labour productivity, p_e a measure of energy prices, p_m import prices and D_t a "demand pressure" variable, as a proxy for short-term fluctuations in returns to capital. All variables are quarterly percentage changes. ε_t is an error term with the usual properties.

The major assumptions implicit in the estimation equation are as follows:

- the mix of inputs in the productive process does not change;
- changes in unit capital costs are only cyclical (and are captured by D), or trend (and are thus picked up by a); and
- the import penetration ratio is constant, when in fact it may, and almost certainly will, vary over time.

The single-equation model employed in this paper treats wages and exchange rates as exogenous. There are, of course, good reasons for endogenising these variables. One reason is that there may be feedback effects from prices to wages. There is some evidence that the dominant causation in the wage-price framework in Australia is from wages to prices and not vice-versa, though this issue is not beyond dispute.[7]

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7. See, for example, Boehm and Martin (1986) who investigate the issue using a VAR analysis of six variables (prices, wages, money, import prices, government current expenditure and the rate of employment). They concluded that "...during periods when the Arbitration Commission applied either full or partial wage indexation, wages generally led prices" (p.19). On the other hand, Alston and Chalfant (1987), who included only three variables find evidence of bi-directional causation between prices and wages, and of causation from money to both prices and wages. Interestingly, Boehm and Martin found no direct effect from money to either prices of wages.

In the event, a single-equation specification has been used, though the authors remain aware of its shortcomings.

(b) Import Prices

For the purposes of the paper, import prices are assumed to be determined by world prices and exchange rates.[8] With variables defined in percentage change form,

$$p_{m_t} = \sum_{i=0}^{n} a_i \, (e.p_w)_{t-i} + \varepsilon_t \qquad (2)$$

where p_w is the world price and e the exchange rate measured as units of domestic currency per unit of foreign currency and ε_t is a white noise error term.

4. Estimation Results

(a) Domestic Prices

The dependent variable is the CPI excluding health. Dummy variables have been included to capture seasonality. Other factors, such as the effects of droughts or floods on food prices, and irregular increases in government charges, continue to affect the data.[9]

The energy price variable is an index of automotive fuel prices obtained from the ABS. As a result the estimates obtained for the energy prices variable are a measure of the sum of the direct and indirect effects of fuel prices on the CPI.

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8. An alternative hypothesis is that domestic influences also affect import prices. One hypothesis would be that there is a second class of imports whose prices are determined by the domestic inflation rate. Another hypothesis would be that the speed of adjustment to exchange rate changes is influenced by domestic factors. These hypotheses were tested but there was little evidence of any such effects. In particular, if there is permanent "absorption" from exchange rate changes the hypothesis of full pass-through from world prices and exchange rates should be rejected, but it is not.

9. There is still a considerable amount of "noise" in the data. Using annual or semi-annual data would eliminate much of this variation. But if non-overlapping data are used, this has the effect of substantially reducing the effective number of observations, while the alternative of using a larger sample of overlapping periods introduces the problem of auto-correlated errors.

A demand pressure variable is included to capture any short-term variations in the return to capital. The variable used is the deviation of non-farm GDP from its trend over the period.

The first estimation issue to be addressed is the length of the lags on the effects of the explanatory variables upon the CPI. Previous Australian studies indicate lags of up to 6 quarters from both wages and import prices; the initial specification follows suit.

Results for the initial equation, estimated using ordinary least squares from 1972(4) to 1986(4), are shown in column 1 of Table 1. The point estimate of the sum of effects from all lags of the three explanatory variables is less than unity. The estimated coefficients on some lags are negative; many estimates have large standard errors.

There could be a number of reasons for these problems. The large number of lags in the specification necessitates a long run of data, over a period when structural change was almost certainly occurring. Those changes had several distinct manifestations. Importantly for the link from import prices to the domestic price level, the import penetration ratio rose steadily through the 1970s and early 1980s.[10] In addition, changes in capital intensity in the wake of the mid 1970's wages explosion could have altered the responsiveness of prices to wage and capital costs.

To explore the question of structural change, an equation excluding the first four years of data from the sample is shown in column 2 of Table 1. Applying a Chow test, the null hypothesis of no structural change can be rejected at the 5 per cent level of significance.

Instability in the behavioural parameters could account for this. But other factors may also be important. It could be that the variance of the disturbance terms is different in the two periods. This could be so if, for example, inflation in the mid 1970s was more variable than in subsequent years.

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10. The ratio of exports to GDP also rose over this period. This would be a further reason for instability because of the influence of domestically-consumed exportables in the CPI. An export price variable was not included, however, because of the already large number of explanatory variables.

Table 1: Estimation of the CPI Equation*

	1	2	3	4	5
Estimation Period	72(4)-86(4)	76(4)-86(4)	78(2)-86(4)	78(2)-86(4)	78(2)-86(4)
Lag Specification	Freely Estimated	Freely Estimated	Almon	Almon	Freely Estimated
Intercept	1.01	.83	.52	.07	.18
	(3.8)	(2.4)	(1.6)	(0.9)	(1.8)
W(0)	.09	- .01	- .01	.04	.10
	(2.1)	(0.2)	(0.3)	(1.1)	(2.1)
W(-1)	.09	.12	.11	.14	.19
	(1.9)	(2.2)	(2.1)	(4.0)	(4.2)
W(-2)	-.06	-.02	.08	.10	-.01
	(0.1)	(0.2)	(2.5)	(2.9)	(4.0)
W(-3)	.03	.04	.04	.05	.07
	(0.5)	(0.7)	(1.2)	(1.8)	(1.3)
W(-4)	.12	.16	.05	.07	.16
	(2.3)	(2.6)	(1.9)	(3.0)	(3.4)
W(-5)	.15	.05	.10	.11	.06
	(2.7)	(1.0)	(2.2)	(3.3)	(1.4)
W(-6)	.05	.07	.11	.08	.05
	(0.9)	(1.1)	(2.0)	(2.2)	(1.2)
PM(0)	.05	.56	.04	.05	.06
	(1.7)	(1.8)	(1.4)	(2.8)	(3.0)
PM(-1)	.01	.01	.04	.06	.02
	(0.5)	(0.3)	(2.5)	(6.8)	(0.8)
PM(-2)	.04	.0	.03	.06	.09
	(1.2)	(.0)	(2.3)	(5.8)	(3.5)
PM(-3)	.02	.03	.03	.05	.05
	(0.6)	(1.2)	(1.9)	(4.5)	(2.1)
PM(-4)	.05	.02	.03	.05	.06
	(1.6)	(0.6)	(1.9)	(4.5)	(2.4)
PM(-5)	.0	.02	.02	.04	.01
	(0.1)	(0.6)	(1.9)	(4.3)	(0.6)
PM(-6)	-.01	.01	.02	.02	.04
	(0.4)	(0.2)	(0.8)	(1.4)	(1.8)
Petrol(0)	.06	.06	0.05	.045	.045
	(3.5)	(4.9)	(5.1)	-	-
Petrol(-1)	0	0	0	.01	0
	(0)	(0.3)	(0)	(1.1)	(0)
Petrol(-2)	.01	0	0	0	.01
	(0.4)	(0.2)	(0.3)	(0.9)	(1.3)
Petrol(-3)	.02	.02	0	0	.01
	(1.2)	(1.3)	(0.4)	(0.4)	(1.1)
Petrol(-4)	-.03	-.01	0	0	.02
	(1.7)	(0.6)	(0.6)	(0.5)	(1.6)
Petrol(-5)	.01	.02	.01	.01	0
	(0.5)	(1.5)	(0.7)	(1.0)	(0)
Petrol(-6)	0	.01	.01	.01	.01
	(0.1)	(0.8)	(0.5)	(1.3)	(1.0)

Table 1: Estimation of the CPI Equation* (continued)

	1	2	3	4	5
Demand	15.6 (2.9)	9.9 (1.9)	6.0 (1.2)	-	-
Dec 78 Excise	-	-	-	1.20 -	1.20 -
ΣW	.48	.41	.48	.59	.61
ΣPm	.02	.12	.21	.32	.33
Direct Petrol	.06	.06	.05	.045	.045
ΣIndirect Petrol	.06	.04	.02	.04	.01
Σ all	.61	.64	.77	1.00	1.00
DW	2.03	1.31	2.40	2.15	1.74
$\bar{R}^2$	.70	.63	.67	.78	.82
Restrictions	-	-	Pet (0) = .045 Σ all = 1.00 Excise = 1.2		Pet (0) = .045 Σ all = 1.00 Excise = 1.2
F statistics on Restrictions (incl. Almon restrictions)			0.85	1.23	0.63
Critical 5% F			2.59	2.91	3.71
n	57	41	35	35	35
df	31	15	29	22	13

* t statistics in parentheses. Seasonal factors omitted for convenience.

In view of the above, a shorter estimation period was used, from 1978(2) to 1986(4), during which the problem of structural change should be less pronounced. To overcome a shortage of degrees of freedom, the Almon technique was employed to restrict the lag structure to be polynomially-distributed. The results are shown in column 3 of Table 1.[11]

In a further refinement in the preferred equation, shown below in Table 2 and in column 4 of Table 1, the coefficients on the three input price variables are restricted to sum to unity, and the direct (i.e. lag zero) petrol price effect to be 0.045, which is approximately equal to its average weight in the CPI over the estimation period. The demand pressure variable is omitted, because of the insignificant parameter estimates obtained in earlier equations (though insignificant petrol price variables are retained). A synthetic variable is included to capture the effects of a significant increase in excise rates on alcohol and tobacco prices in the December quarter of 1978.

The three restrictions could not be rejected jointly at the 5 per cent level. The Durbin-Watson statistic, though close to 2, was in the inconclusive region at the five per cent level of significance, due to the relatively large number of regressors. A Box-Pierce test could not

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11. There are, of course, a number of problems in the use of Almon lags. However, the results which were obtained do not appear to be peculiar to the choice of the Almon lag formulation. The polynomial lags for each variable were fitted using the method suggested in the literature on distributed lags. (See, for example, Trivedi and Pagan (1976).) Longer lag structures were tested but the hypothesis that the lag length was only six quarters could not be rejected. Tests for the appropriate degrees for the polynomials indicated that a second-order polynomial could describe the lags on import prices and petroleum prices, but that a fourth order polynomial was required to describe the lag structure on unit labour costs. The restrictions implied in the Almon lag formulation, were tested against a freely estimated equation and could not be rejected. Furthermore, the estimates obtained for the weights on each variable in the Almon lag equations are very similar to the freely-estimated weights. This suggests that the results derived below for the long run effect of import price (and exchange rate) changes would be valid without assuming Almon lags.

Table 2: Preferred CPI Equation (Almon Lags)
(t statistics shown in parentheses)

		w_{t-i}	Pm_{t-i}	$Petrol_{t-i}$	Intercept
LAG	0	.041	.051	.045	.07
		(0.6)	(2.1)	-	(0.9)
	1	.145	.055	.009	
		(1.8)	(3.9)	(1.1)	Dec 78 Excise
	2	.088	.056	.005	1.20
		(2.9)	(3.9)	(0.9)	
	3	.053	.053	.003	Seasonals
		(4.9)	(3.3)	(0.4)	
					March -.12
	4	.066	.047	.003	(0.9)
		(5.1)	(3.2)	(0.9)	
					Dec. .20
	5	.122	.036	.007	(1.7)
		(3.4)	(2.3)	(0.9)	
	6	.079	.023	.012	
		(2.5)	(0.6)	(0.8)	
		Σ=.595	Σ=.322	ΣDirect = .045 ΣIndirect = .039	

Estimation period: 1978(2) - 1986(4), n=35, df=22

DW = 2.15 R^2 = 0.85 $\bar{R}^2$= 0.78

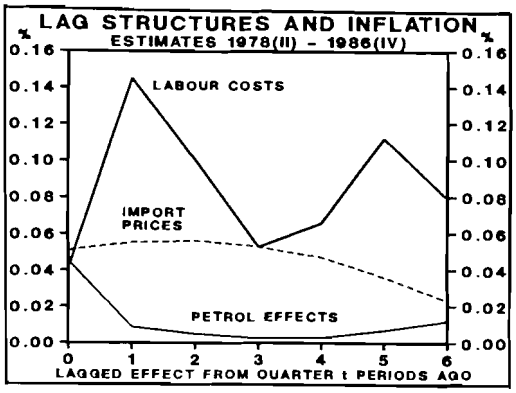
Restrictions: Σ all = 1.00,
Petrol (0) = .045,
Dec '78 Excise = 1.20.

F statistic on restrictions = 1.23, Critical 5% F= 2.91

reject the hypothesis that the residuals were free from first to twelfth-order autocorrelation (though it should be noted that, in this instance, this is not a powerful test).[12]

The estimated coefficients in the preferred equation shown in Table 2 indicate total weights for unit labour costs and import prices of .59 and .32 respectively, and 0.05 and 0.04 respectively for the direct and indirect petrol effects. The pattern of each effect is shown in Figure 2 below.[13]

Figure 2



12. An examination of the correlation matrix of the regressors indicated both the import price variable and the petroleum price variable tended to be reasonably highly correlated with their own lagged values. However, as Belsley (1986) points out, it is the collinearity or conditioning of the original data series and not the first-differenced series which is important for the reliability of the estimates. An examination of the collinearities of the original series (using the method suggested by Belsley, Kuh and Welsch (1980)) suggests that the important collinearities in the data are limited to the different lags of the same series. This will lead to inefficient estimates of the particular lag structures but should have less effect upon the estimates for the total effect from each series. This suggests that collinearity amongst the dependent variables is unlikely to have had a major effect upon the estimates which are of the most interest in the present study.

13. The weights on the preferred equation which employs Almon lags can be compared with the weights from a freely estimated lag structure where the weights are also constrained to sum to unity. As can be seen in column 5 of Table 1, the estimated weights for each variable are quite similar suggesting that the coefficient estimates are not peculiar to the assumption of Almon lags. Furthermore, in neither case could the restriction that the weights summed to unity be rejected.

(b) Import Prices

For import prices, Equation 2 was estimated using ordinary least squares. For this purpose, the world price index was converted into domestic currency terms, using the Trade Weighted Index of the Australian dollar. The weights in that index are based on import as well as export shares, but they are not much different to the weights in the world price index. The world price and exchange rate variables were collapsed into a single variable representing foreign export prices in Australian currency units. (An F-test showed that the hypothesis of similar lag coefficients on each could not be rejected.)

The equation is estimated from the early 1970s, when the TWI was first calculated. It shows fairly short lags, with the full effect from foreign prices and exchange rates being reflected in import prices within about four quarters.

In preliminary estimations the equation substantially underpredicted the 9.3 per cent increase in import prices that occurred in the September quarter of 1973. It seems plausible that the residual (nearly twice as large as any other residual in the estimation) is related to the 25 per cent across-the-board tariff cut of 18 July 1973. Since the dependent variable measures import prices before tariffs and quotas, the large rise in import prices in that quarter could reflect foreign suppliers lifting their home-currency prices to absorb some of the benefits of the tariff cut. Accordingly, in refining the equation, a synthetic variable for the tariff cut is included, taking a value of 3.0 per cent in 1973(3).[14]

A further refinement is to test and then impose the restriction that the sum of the lag coefficients on the foreign price variable is unity, in order to assess the hypothesis of full pass-through from changes in world prices and in the exchange rate.

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14. When a dummy variable for the tariff cut is freely-estimated in the equation it shows a once-off effect of over 6 per cent . Some simple calculations suggest this is too high. If the average tariff rate for endogenous goods were 15 per cent, the tariff cut would have cut average tariff rates to 11.25 per cent. This would imply that foreigners could lift their home-currency prices by up to 3.4 per cent without increasing their Australian dollar after-tariff price.

The equation resulting from these modifications is shown in Table 3 below.

Table 3: Preferred Import Price Equation

(t statistics shown in parentheses)

$$p_m = \underset{(0.2)}{-.04} + \underset{(11.1)}{.49}\ e\ p_w + \underset{(7.7)}{.34}\ e.p_w(-1) - \underset{(0.6)}{.03}\ e.p_w(-2) + \underset{(3.9)}{.19}\ e.p_w(-3)$$

$$+ \text{Tariff Variable}$$

Estimation period: 1972(3)-1986(4), $n = 58$, $df = 54$

$DW = 2.30$ $R^2 = .76$ $\bar{R}^2 = .75$

Restrictions: $\Sigma e.pw = 1$,

Tariff = 3.0.

F statistic on restrictions = 1.89, Critical 5% F = 3.18

The estimates obtained are in line with expectations, except for a negative estimate on the second lag of the foreign price variable. The coefficient was, however, statistically insignificant.
The restrictions on the sum of elasticities and the tariff variable could not be rejected at the 5 per cent level of significance.[15] The Durbin-Watson statistic indicates the absence of first-order auto-correlation, while a Box-Pierce test did not reveal any higher-order auto-correlation.

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15. The finding of full pass-through (with quite short lags) from changes in world prices and exchange rates is consistent with the findings of the Bureau of Industry Economics (BIE, 1986). Those survey results imply that changes in the exchange rate in 1985 were reflected almost fully in prices paid by importers with relatively short lags.

    A further finding of that survey was that importers were slow to pass through the full effects of their cost increases to retailers or final users. There is, however, no reason to expect that this will adversely affect the estimates of the following two sections of the effect of exchange rate changes upon the CPI. In particular, the conditions which might cause changes in importers' margins have existed at other times in the sample period, so it is likely that this type of "absorption" has also occurred at other times in the sample. As a result, the effect of any slow pass-through from import prices to final prices is likely already to be captured in the estimated CPI equation.

5. The Effects of the Depreciation

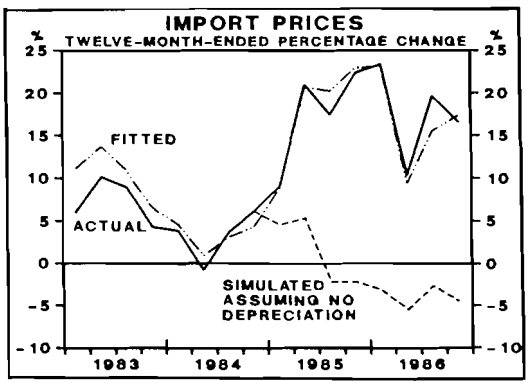
This section describes a "no-depreciation" counterfactual simulation, using the CPI model described in Section 3 and estimated in Section 4.

(a) Import Prices

The major effect of the depreciation upon domestic prices will be from its effect upon import prices. The equation estimated in Section 4(b) can be used to obtain an estimate for the effect of the depreciation upon import prices.

The equation estimates an increase in import prices over the two years to December 1986 of 44.4 per cent, compared with an actual increase of 42.7 per cent. Using the parameters of that equation, and the assumption that the exchange rate remains unchanged from its December quarter 1984 level of TWI=81.8, the "no-depreciation" path for import prices (in twelve-months-ended change form) is shown, along with the in-sample estimates and actuals, in Figure 3 below.

Figure 3



The counterfactual simulation suggests that the depreciation boosted import prices by nearly 50 per cent in the two years to to end-1986. This suggests that import prices might have fallen by around 5-1/2 per cent over the same two year period if the the exchange rate had not depreciated.

This finding can be compared with the experience of other industrialised countries. To this end data (shown in Appendix 2) for import prices for 16 other OECD countries were collected. All sixteen countries show falls in import prices (measured in their own currencies) over the twelve months to September 1986, except for Norway, where there was no change in import prices over the period. This was despite the fact that a number of the countries experienced substantial depreciations over the period. Some further figuring, also in Appendix 2, suggests that after removing the effects of changes in exchange rates and oil prices, import prices fell, on average, by around 7 per cent in the year to September 1986 in these countries. Thus the finding above that, had it not been for the depreciation, Australia might have been experienced falling import prices is consistent with the experience of other countries.

(b) Domestic Prices

To estimate the total effects of the depreciation upon the domestic price level, the mark-up model estimated in the previous section is used for a counterfactual simulation. For this purpose:

- the "no depreciation" path for import prices generated in Section 5(a) is used;

- the effect of the depreciation is removed from petrol prices, based on calculations by the Prices Surveillance Authority; and

- wages under the "no-depreciation" scenario are assumed to be unchanged from the actual historical outcome.

For petrol prices, the Prices Surveillance Authority has dissected changes in the maximum wholesale price of petrol into the effects of exchange rate changes, supply cost changes and changes in excise and other government charges.[16] The removal of the exchange rate effect from petrol prices reduces petrol prices in the December quarter 1986 by around 12-1/2 per cent.

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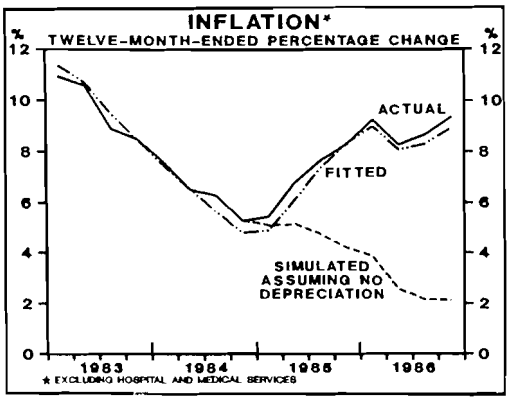
16. Because the Import Parity Price is calculated against the U.S. dollar, these calculations show the effect upon petrol prices of our depreciation against the U.S. dollar, rather than against the TWI.

The path generated for the CPI excluding health under these assumptions is plotted against the estimated path generated by the sample data, as well as the actual outcome, in twelve-months-ended form in Figure 4 below.[17]

Figure 4



Using historical data for the eight quarters to December quarter 1986, the model estimates that the CPI (excluding health) grew by 18-1/2 per cent. Over the same period, the "no-depreciation" simulation shows growth of only 6-1/2 per cent, suggesting that the depreciation contributed around 12 percentage points to the CPI over the two years. The model implies a total long run effect of the depreciation of the order of 18 percentage points.[18] Given the depreciation of around 51 per cent against the TWI (when measured in units of domestic currency per unit of foreign currency), this would imply that the CPI responds to changes in the TWI with an elasticity of around 0.35.

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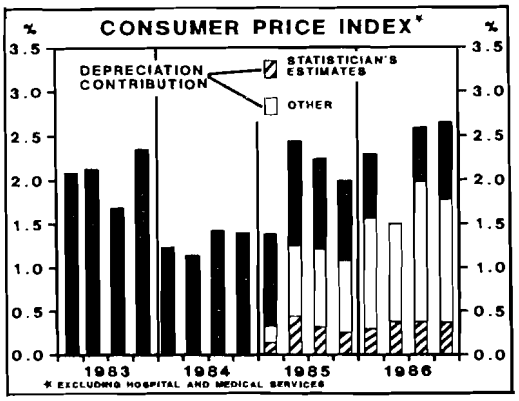
17. Note that Figure 4 shows a counterfactual path for the CPI excluding hospital and medical services, which in the year to December 1986 grew substantially faster than the rest of the CPI. If it is assumed that the prices of hospital and medical services have been affected by depreciation to a similar extent to the rest of the CPI the counterfactual simulation for the total CPI would be higher by around 0.5 percentage points in the year to December 1986.

18. Some rough calculations for the March, June, and September quarters of 1987 suggest a further depreciation effect of around another four percentage points, suggesting that only a relatively small proportion of the total effect was then yet to impact upon the CPI.

The estimates for the effect of the depreciation upon the CPI are shown in quarterly form in Figure 5 below, along with the Statistician's estimates of the direct contribution of increases in the prices of goods and services which are wholly or predominantly imported.

Figure 5



Not too much importance should be placed on the particular point estimate of the depreciation effect. There is likely to be some simultaneity bias. For example, had there been no depreciation, wages may have behaved differently.

While there was explicit discounting for at least part of the depreciation effect at National Wage hearings, earnings "drift" was quite strong over 1986. Wage growth could easily have been lower had the depreciation not occurred. This suggests that the estimates of the depreciation effects could be too small. On the other hand, economic policies generally, particularly monetary policy, were tightened as a result of the same circumstances which produced the depreciation, implying slower inflation than would otherwise have occurred. This imparts some bias in the other direction. It is not possible to be certain how these effects will net out in the final analysis.

But it remains to be said that the findings here are of interest since they suggest that the responsiveness of domestic prices to the exchange rate is greater than has been found in most earlier studies. Fallon and Thompson (1987), for example, cite three earlier studies[19] which show, according to their calculations, total exchange rate "elasticities" of around 0.23, compared with this study's estimate of 0.35. Fallon and Thompson themselves use a completely different methodology, applying the IAC's ORANI model to capture the effects of depreciation upon the different sectors of the economy. Their analysis is more detailed, and includes an explicit consideration of capital rental costs. Their results show a total elasticity of around 0.36, supporting the notion of a larger effect. Furthermore, they are able to calculate effects on various types of goods, for example exportable, import-competing, and non-tradeable goods. The estimates of this paper might be regarded as complementing the Fallon and Thompson estimates, by providing an estimate of the timing of these depreciation effects.[20]

6. Conclusion

This paper has presented some estimates of the effect of the recent depreciation of the $A on the Consumer Price Index. The estimated effects are substantial.

Placed in an international perspective, this is not surprising. The evidence suggests that the export prices of Australia's main suppliers have fallen in the recent past. Thus, had it not been for the depreciation, Australia would have been importing the effects not of world inflation, but of world deflation. This lowers the base against which the actual inflation rate is, ideally, to be compared, and makes the measured depreciation effect correspondingly larger.

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19. By the Treasury (NIF-10), Nevile and the Economic Summit Model.

20. It should be noted that the estimates of this paper use calculations of the effect of changes in the A/US rate upon petrol prices, based on existing government revenue arrangements. Fallon and Thompson appear, however, to assume that petrol prices would be affected by the full magnitude of depreciation, which in the current example is around 51 per cent on a trade-weighted basis. If the calculations of this paper were made under similar assumptions, the total elasticity obtained would be somewhat higher.

Even so, the results suggest a larger response to exchange rate changes than had been found in most earlier studies. This is a plausible result, in view of the increased openness of the Australian economy over the sample period.

The findings also have implications for prospects for inflation in the near future. Given the finding that almost all of the price effects from the depreciations of 1985 and 1986 had passed by late 1987, and the fact that the Australian dollar has been more stable in 1987 than in the previous two years, it follows that most of the exchange rate effects upon the CPI should have passed by late 1987. If the currency remains relatively stable, any further imported cost pressures should be limited to those movements which occur in world traded goods prices. This implies that the major factor determining the differential between Australian and overseas inflation rates will be growth in Australian unit labour costs relative to those overseas. If growth in domestic labour costs is close to that in our major trading partners, there is a good prospect that the rate of inflation could fall into line with inflation rates in those countries.

APPENDIX 1: THE MARK-UP MODEL OF INFLATION

Let the aggregate price of consumer goods be PC_d. This is a weighted combination of the price of domestically-produced consumer goods, P_d, and the price (in domestic currency) of foreign-produced consumer goods P_f:

$$PC_d = (1-\delta)P_d + \delta P_f \qquad (1)$$

where δ is the weight, and can be thought of as the import penetration ratio.

P_d can be thought of as a mark-up on costs of production. Let the production function for domestic consumer goods be represented by

$$Y = F(K,L,E) \qquad (2)$$

where K and L represent capital and labour, respectively, and E represents energy input, along the lines proposed by Helliwell et al.[1] If F is homogeneous of degree one, then competitive equilibrium requires that

$$P_dY = WL + RK + P_EE \qquad (3)$$

where W is the wage rate, R the rental cost per unit of capital and P_E the price per unit of energy. This then implies that

$$P_d = \frac{WL}{Y} + \frac{RK}{Y} + \frac{P_EE}{Y} \qquad (4)$$

- the unit price is the sum of the unit costs for labour, capital and energy.

If lower case letters are used for proportionate rates of change, then for small changes, the rate of change of P_d is approximately given by

$$p_d = \alpha[w + (l-y)] + \beta[r + (k-y)] + \gamma[p_e + (e-y)] \qquad (5)$$

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1. See Helliwell, Boothe and McRae (1982). The specific effect to be captured here is the importance of oil in the productive process, and thus of oil prices for prices generally.

where α, β and γ are the proportions of labor, capital and inputs into the productive process ($\alpha + \beta + \gamma = 1$). If unit capital costs do not change, the second term is zero, and price movements are left as being explained by changes in unit costs of labour and energy.

If an import price index, P_m, is used to represent P_f, and rates of change of (1) are taken and (5) substituted into the resulting equation, the following equation is obtained:

$$pc_d = \alpha(1-\delta)[w + 1 - y] + \gamma(1-\delta)\ [p_e + e - y] + \delta p_m \qquad (6)$$

Allowance can be made for the fact that the economy could be off this competitive pricing relationship in the short run. A conventional approach is to allow some lagged adjustment, as in (7):

$$pc_d = (1-\delta)\ [\alpha\ \Sigma_i \eta_i (w+1-y)_{t-i} + \gamma\ \Sigma_i \theta_i\ (p_E + e-y)] + \delta\ \Sigma_i \mu_i p_{m_{t-i}} \qquad (7)$$

Because labour productivity as measured may contain a large component of noise, trend productivity growth may be used. This can be accomplished either by allowing a separate constant term in (6), or (which amounts to the same thing) by specifying the unit labour cost variable as $w_{t-i}-z$, where z is the trend growth rate of productivity. In addition to this, the "energy productivity" term in (7) can be subsumed into a constant.

It is difficult to think of any satisfactory direct measurement of unit capital costs[2]. However, because rates of return to capital may vary with the economic cycle, a demand-pressure term can be included to proxy movements in profit margins and hence in returns to capital. A typical variable is the deviation of output from some trend growth path, denoted below as D.

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2. Excluding the effect of changes in the capital-output ratio (K/Y), unit capital costs are explained by movements in R, the aggregate rate of return to capital. Measurement of this rate of return is, however, close to impossible. Its short-term movements are probably not well-proxied for the present paper by any conventional market interest rate. In the longer term, excluding the possibility of secular shifts in real rates of return or in inflation rates, it may be safe to assume that the rate of return to capital does not substantially change, and that nor in turn do unit capital costs.

The specification that is obtained is then

$$pc_{d_t} = a + \sum_{i=0}^{\ell} b_i(w_{t-i} - z) + \sum_{i=0}^{m} c_i\, Pe_{t-i} + \sum_{i=0}^{n} d_i Pm_{t-i} + eD_t + \varepsilon_t \qquad (8)$$

where $b_i = \alpha(1-\delta)\eta_i$, and $c_i = \gamma(1-\delta)\theta_i$ and $\phi_i = \delta\mu_i$.

It can be seen that (8) embodies the restrictions that:

- the mix of inputs in the productive process (described by α, β and γ) does not change;
- the change in the efficiency of use of energy (the (e-y) term in (7)) is zero, or some non-zero constant;
- changes in unit capital costs (r + k - y) are only cyclical (and are captured by D), or trend (and are thus picked up by a);
- the import penetration ratio (δ) is constant, when in fact it may, and almost certainly will, vary over time.

Given that these restrictions are imposed, one might expect to find the performance of the model deteriorating under some plausible conditions:

- if over time the relative proportions of labor, capital and energy in the productive process altered, consumer prices might become more or less sensitive to changes in wages;
- if capital costs increased sharply, the model would underpredict the rise in prices;
- the model will under or over-predict the effect of import prices as the import penetration ratio rises above or falls below its sample mean.

An additional feature of the pure mark-up model discussed above is that it ignores the important notion of substitutability between domestic and foreign goods. In the context of (1), allowance for substitutability might be expressed as:

$$\frac{\partial PC_d}{\partial P_f} = \delta + (1-\delta)\frac{\partial P_d}{\partial P_f} \qquad (9)$$

In the event of a substantial currency depreciation by a small country, the price of imports will rise (abstracting from "absorption"). Prices of domestic substitutes may be expected to rise as well - the greater the cross elasticities, the greater the rise in domestic prices. In the extreme case of perfect substitutes and atomistic world markets, P_d will move up to the new world price measured in domestic currency (i.e. $\partial P_d/\partial P_f = 1$), and the rise in domestic prices will be exactly equal to the rise in import prices (i.e. $\partial PC_d/\partial P_f = 1$).

In the more general case of significant but imperfect substitutability the sum of the estimates of the d_i in equation (8) is likely to be of a larger magnitude than the import penetration ratio (or in a computational sense, the weight of imported goods in the price index used), since it will pick up a substitution effect.

APPENDIX 2: INTERNATIONAL IMPORT PRICE EXPERIENCE

This Appendix looks more closely at international import price experience. The table below (from OECD and country sources) shows movements in import prices and effective exchange rates for 16 OECD countries. As can be seen, there was not a single country to experience rising import prices in their own currency in the period in question. This was despite the fact that a number of the countries experienced substantial depreciations over the period.

Import Prices and Exchange Rates[1]

(twelve months to September 1986)

Country	Movement in Import Prices	Movement in Exchange Rates
Japan	-42.9	-28.5
Italy	-22.0	-4.8
Germany	-21.8	-8.2
Netherlands	-19.7	-6.6
Belgium	-18.3	-4.5
Finland	-16.0	-0.5
France	-16.0	-0.2
Denmark	-14.0	-5.8
Sweden	-12.3	3.0
Austria	-11.7	3.5
Switzerland	-11.4	-10.4
United Kingdom	-7.3	17.8
USA	-4.3	22.5
New Zealand	-4.1	26.9
Canada	-2.0	5.7
Norway	0.0	10.5

In an attempt to quantify the various factors (including currency movements) influencing import prices over the period, a simple cross-section regression was conducted. The estimated equation was as follows:

$$p_{m_i} = \alpha_1 + \alpha_2 \, er_{0_i} + \alpha_3 \, er_{-1_i} + \alpha_4 p_i + \alpha_5 \, Oil_i + \varepsilon_t$$

where

p_m = percentage change in import prices in year ended Sept. 86.

er_0 = percentage change in exchange rate in year-ended Sept. 86[1].

er_{-1} = percentage change in exchange rate in year-ended Sept. 85.

p = change in GDP deflator in year-ended Sept. 86.

Oil = share of oil in total imports in 1984

and the subscript i refers to each country i = 1 to 16.

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1. The exchange rates here are defined as units of domestic currency per unit of foreign currency.

The second exchange rate term is included to capture possible lagged effects from exchange rates changes. The domestic price variable is included to capture the possibility that foreign suppliers' pricing behaviour is partly determined by the objective of market share preservation. The oil price variable is included to capture direct oil price effects, since the import price data shown above are for all imports, including petroleum imports. The expected signs of α_2, α_3 and α_4 are positive. The parameter α_5 should be equal to the percentage change in oil prices over the period. Finally, α_1 should represent that movement in import prices which cannot be explained by exchange rate changes, differential domestic inflation rates or direct oil price effects. It should therefore be the underlying movement in the price of non-oil imports over the period.

In the initial estimation, the first exchange rate term was statistically very significant and showed the expected sign. The second exchange rate term and the domestic inflation show the expected sign but were not statistically significant. The oil price effect was highly significant, though somewhat larger (-0.8) than one might expect given the fall in oil prices over the period of around 50 per cent.

In the preferred equation, the oil price effect was constrained to -0.5 (the approximate fall in oil prices over the period) and the second exchange rate and domestic inflation terms were omitted. The equation is shown below.

International Import Prices Equation

$$pm = -6.98 + 0.52\ ER1 - 0.5\ Oil$$
$$\quad\quad (7.1) \quad (7.0)$$

n=16, df=14

$\bar{R}^2 = 0.86$ Restriction: Oil = -0.5, F statistic = 3.38

Critical 5% F = 4.67

Because heteroskedasticity is often a problem in cross-sectional regressions, the Breusch-Pagan test was employed and could not reject the hypothesis of uniform variance of the errors. The results do not seen sensitive to the exclusion of either Japan (which shows the largest fall in import prices) or the United States (which would be most subject to "large country" effects).

The constant term in the above equation can be interpreted as an estimate of the average movement in non-oil import prices, apart from exchange rate effects over the period. That is, the "underlying" movement in non-oil import prices for these 16 countries is estimated to have been significantly negative. According to these estimates, the underlying movement was a fall of around 7 per cent.

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