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Exchange Rate Pass-Through and Irish Import Prices

by

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Summary

This study assesses the extent to which exchange rate changes affect Irish import prices (i.e. the extent of exchange rate pass-through, PT). The analysis covers the period 1963-1995 and makes use of the Johansen cointegration technique. The paper thus fills two important gaps in the literature, as highlighted by Menon (1995) in his recent PT survey, i) by making due allowance for the time series properties of the data and ii) by concentrating on the case of a small open economy.

The majority of international empirical studies in the area do not provide support for full, or close to full, PT. Reasons put forward for this finding include the "menu" and supply costs associated with altering prices, hedging techniques, intra-firm pricing by multinationals, the existence of non-tariff barriers, and the entry/exit of firms associated with exchange rate induced price changes.

In order to assess the extent of PT for Irish import prices, a widely-used mark-up model is employed. This model relates import prices to the exchange rate, foreign costs and domestic competing prices. The usual approach involves estimating a single equation containing these variables (with import prices being the regressand) and using the estimated coefficients to assess the degree of PT. It is argued in this paper, however, that such single equation estimation will lead to seriously biased and inefficient estimates, as due account is not being taken of the strong simultaneity of import prices and domestic competing prices. More precisely, the failure to take account of simultaneity can give rise to estimates of the degree of PT which are too low.

This study makes use of the Johansen technique to allow for such simultaneity and uncovers *two* long-run equilibrium relationships among the data, i.e. one between import unit values, the exchange rate and foreign costs and another between domestic competing prices and the same two variables. In so doing, it confirms the existence of very close to full PT in the case of *both* Irish import prices and domestic competing prices. Many of the previous results in the literature demonstrating substantially less than full PT may be due to a failure to make proper allowance for the time series properties of the data or for the strong simultaneity which exists between import and domestic competing prices. Finally, it is found that the speed of adjustment to the long-run relationships appears to be quite slow, thus supporting the existence of incomplete PT in the short run.

1. Introduction

Menon (1996) defines exchange rate pass-through (PT) as "the degree to which exchange rate changes are reflected in the destination currency prices of traded goods" (p. 434). Given the lack of response of trade flows of major trading economies to dramatic movements of their nominal exchange rates over the past two decades, there has been an extensive investigation into the possibility of incomplete PT as a possible explanatory factor. Indeed, Menon (1995a) reports in a recent survey of the literature that incomplete PT appears to be a very common phenomenon across a wide range of economies. The objective of this paper is to examine the degree of PT in Ireland, together with its dynamics, for the specific case of Irish import prices[1]. Ireland is a classic example of a small open economy (SOE), and in the paper we compare our results with those previously obtained in the PT literature. We also highlight what we view as shortcomings in the mark-up approach of previous authors in this area such as Menon (1995b) which, we believe, lead to an underestimation of the degree of PT, and illustrate our proposed method of overcoming them. In so doing we make use of the "Johansen technique", thereby fully taking into account the non-stationarity of our data and the endogeneity of the variables covered. Our approach thus fills two of the gaps outlined by Menon in his PT survey, whereby he argued that PT studies to date have not paid enough attention to either the time-series properties of data or to small economy examples.

As a precursor to the analysis itself, section 2 briefly discusses some of the underlying theoretical issues surrounding PT. Section 3 outlines the modelling strategy upon which we base our approach and in section 4 some informal chart-based analysis of the variables is undertaken as a precursor to the formal econometric work. In section 5 we present and discuss our econometric results, while the final section summarises and concludes.

[1] The macroeconomic relevance of import price determination, particularly in a small open economy like Ireland, is clearly indicated by the large share of imports in aggregate economic activity. In 1995, for example, recent CSO estimates suggest nominal import shares of 75.3% and 65.9% in GNP and GDP respectively.

2. Some Underlying Theoretical Issues

According to the small open economy (SOE) view of price determination, one would expect complete PT from any change in the exchange rate into the Irish pound price of imports. Under this view, purchasers/consumers of foreign imports in Ireland are seen as price-takers. Foreign producers set their (foreign currency) prices as a constant mark-up over cost. Thus, in order to protect their mark-up (profit margins) in foreign currency terms, importers into Ireland will alter the Irish pound price of imports to offset completely any change in the exchange rate.

Short-run incomplete PT is, however, easy to envisage from a microeconomic perspective and could arise from factors such as menu costs associated with changing prices, inertial behaviour by firms in altering their usual supply patterns[2] due to the costs involved, delayed consumer demand reactions to price changes and payment lags and hedging techniques. Other, more fundamental microeconomic reasons for this outcome also exist, however. For instance, in the beachhead model developed in Baldwin (1988), large enough changes in the exchange rate can induce entry of firms into the market and the presence of additional entrants can affect pricing behaviour. Firms may, for example, be willing to vary their profit margins in order to protect market share. Another way in which exchange rates may not fully feed through to prices is where MNC's are involved in intra-firm trade to offset the full transmission of exchange rate changes to selling prices in individual markets. Finally, where there are quantitative restrictions on trade, Bhagwati (1988) has argued that this can lead to incomplete PT. Menon (1994, 1995a) describes both the short-run and more fundamental ways in which the above factors can lead to incomplete PT in some detail.

The most important issue which needs to be addressed when discussing exchange rates and prices is whether incomplete PT persists in the long run. Empirical applications of the PT literature can be broadly divided into disaggregated, or microeconomic, approaches and those which make use of aggregate macroeconomic trade data. When

[2] Prices are, for example, only likely to be lowered gradually in response to an exchange rate appreciation, as it takes time for firms to expand their supply capacity in response to price reductions. Over time, pass-through should, however, be complete. This is associated with the pricing to market literature of Krugman (1987).

discussing PT in a macroeconomic context, the validity or otherwise of purchasing power parity (PPP) in the traded sector as a long-run working proposition is crucial in assessing the likelihood of incomplete PT in the long run. In a recent survey of the PPP literature, Froot and Rogoff (1995) argue that, although earlier tests of (broad) PPP were generally unsupportive of the proposition, later tests using longer runs of data have provided the theory with more backing. Very long stretches of data are required due to the low power of the tests used. These tests are usually framed in a way in which a nonstationary real exchange rate (depicting the absence of PPP) is the null hypothesis. Given the relatively long half-life of deviations from PPP, in the absence of long runs of data the null will not be rejected, even in cases where such rejection is warranted. Overall, Froot and Rogoff conclude that "there does seem to be long-run convergence to PPP" (p. 1683) and we would concur with such a view. We would, accordingly, be somewhat sceptical of evidence suggesting substantive deviations from full PT in the long run using traded prices or indeed when using profit mark-ups on cost instead of the foreign traded price variable[3], upon which the literature in this area concentrates[4].

Menon (1993a) argues that "the trend in this literature has been to move away from the macro scene and to focus, instead, on particular industries of interest. This approach avoids many pit-falls associated with aggregative studies, especially the bias infused into pass-through estimates as a result of the aggregation of different classes of goods" (p. 93). While we would admit that there are indeed difficulties associated with a broad macroeconomic approach to the PT question, failure to address the issue in such a context can lead to an even greater degree of misunderstanding. The partial nature of disaggregated studies means that findings of incomplete PT, while very interesting in themselves, should not be adduced as evidence that this result carries over to the broader macroeconomy. It is easy to envisage such partial studies throwing up findings of incomplete PT while full transmission of the exchange rate to overall prices takes place in the long run. Therefore, in order to focus on the

[3] See, for instance, the mark-up model presented in Section 3 below.
[4] More narrowly, in the context of this paper, given Ireland's SOE status, we would expect that importers would face perfect elasticity of supply, so that, being price-takers, PT should be complete in the long run. For earlier evidence in support of this hypothesis, see Browne (1983).

macroeconomics of the PT question, this paper examines the issue using an aggregate index of import prices.

3. Underlying Model

Many previous studies in this area have made use of a simple mark-up model to derive the import price equation used to test for PT. It is argued that this approach is more appropriate for the types of goods involved in international trade where imperfect competition prevails. Menon (1995b, 1996) makes use of the following model in studies using both macroeconomic and industry level data respectively. First it is assumed that producers abroad set their foreign currency export price (PX) as a mark-up (π) on their cost of production in foreign currency terms (CP)[5]:

$$PX = \pi \, CP \tag{3.1}$$

The domestic currency (i.e. Irish pound) import price (PM) is, therefore, given by:

$$PM = PX \; ER = (\pi \, CP) \; ER \tag{3.2}$$

where ER is the exchange rate defined as the domestic currency price of one unit of foreign currency[6]. It is assumed that the mark-up depends on competitive pressures in the domestic market, and the exchange rate. This competitive pressure is proxied by the gap between the price of import-competing goods (PD) and the exporter's production cost. Accordingly the profit mark-up is modelled as:

$$\pi = \{PD/(CP \; ER)\}^{\alpha} \tag{3.3}$$

Substituting equation (3.3) into equation (3.2) we obtain:

$$PM = \{(PD/CP \; ER)^{\alpha}\} \; \{CP \; ER\} \tag{3.4}$$

[5] The mark-up π is equal to $1 + \lambda$, where λ is the profit margin.
[6] Along the lines of the mark-up models generally used in this literature, we abstract, for simplicity, from importers' profit margins.

Taking natural logarithms of the variables and denoting them by lower case letters, equation (3.4) can be reformulated as follows:

$$pm = \alpha\, pd + (1-\alpha)\, cp + (1-\alpha)\, er \qquad (3.5)$$

The procedure adopted by Menon and others involves running a regression of the above form. If α, the estimated coefficient on pd is zero, the restrictions implied by the model are taken to mean that the coefficient on foreign costs and the exchange rate will be unity and that PT will, accordingly, be complete[7]. On the other hand, where α is found to be unity, the coefficient on foreign costs and the exchange rate will be zero and this is interpreted as implying zero PT[8].

One serious difficulty with the above approach is the potential endogeneity of several of the regressors in equation (3.5). In the case of SOE's, it is very likely that pd will be endogenous with respect to cp and er, with coefficients approaching unity in the long run[9]. Similarly, it may not be feasible to treat the nominal exchange rate, er, as being exogenous with respect to domestic price developments relative to those prevailing abroad. While these problems may not be as severe for the estimation of individual industry equations of the type used in disaggregated studies, they become very serious when dealing with macroeconomic variables. When estimation is performed using single equation techniques these problems will lead to biased and inefficient coefficients and it is difficult to see any satisfactory way of resolving this issue under such circumstances. Hence, the estimates presented in Menon (1993a, 1996), and other similar studies, although dealing with disaggregated data, must be treated with caution. Menon (1995b) makes use of the Johansen procedure which employs a simultaneous equation maximum likelihood technique that allows for the

[7] From (3.3), a finding of $\alpha = 0$ would also imply that the foreign mark-up is independent of domestic competing costs, the exchange rate or foreign cost considerations.

[8] As Menon (1993a) points out, most studies in the PT literature make use of a representative "world" price rather than a cost variable. This price represents the pricing decision of foreign producers to all markets and not just to the home market, however. Where pricing to individual markets prevails, the utilisation of such a variable must, therefore, be questioned. The use of a foreign cost variable does not suffer from such drawbacks, however, as this cost does not depend on the particular export market being targeted.

[9] See sections 4 and 5 for evidence on this.

estimation of more than one equilibrium relationship among the data in question. However, he interprets his results as providing backing for only a single cointegrating vector for his Australian data, although, as we will argue later, the case for having done so does not seem to have been particularly convincing.

4. Informal Chart-based Analysis

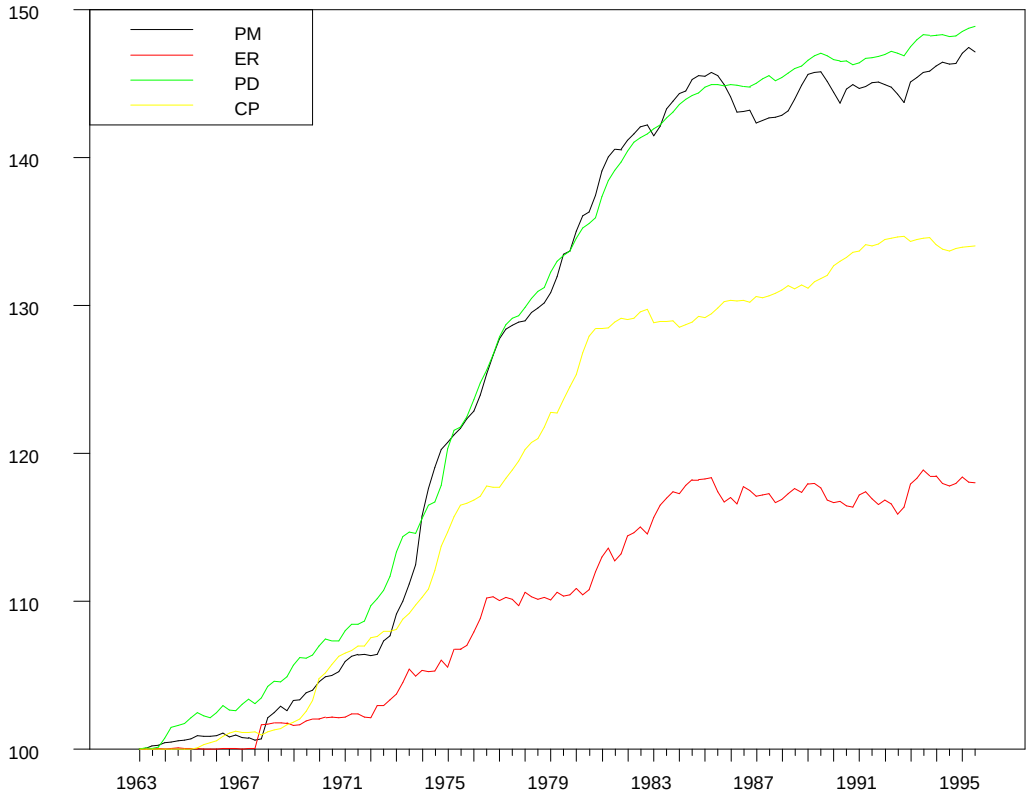
Chart 1 (see below) depicts the four main variables used in our study, with each having first been logged and then based to a value of 100 in 1963. PM represents import unit values, PD represents Irish manufacturing output prices i.e. the domestic competing price, ER is the nominal exchange rate weighted by import shares accounted for by the UK, the US and Germany[10], while CP is an import-weighted average of unit labour costs in these three countries. Further details of the data used, together with the sources, are presented in the Data Appendix.

The most striking feature to emerge from the chart is the strong similarity between the PM and PD price variables (the top two lines in the chart). This, however, is only to be expected given that Ireland is a classic example of a SOE. Given these data, it is hard to envisage extracting a single long-run relationship between PM, ER and CP if the domestic price, PD, was to be included in the analysis. Indeed, as Hansen and Juselius (1995) argue, a variable that is highly relevant can get an insignificant test value for the null hypothesis of exclusion from the cointegration space if it exhibits strong multicollinearity with other variables in the analysis (p. 64)[11].

[10] In terms of share of imports these are our three most important trading partners. There is, however, a more fundamental reason for concentrating upon these three countries: the UK has been our dominant trading partner since the inception of the state; Germany can be used as a proxy for the remaining European nations; the US, finally, is used as a proxy for the rest of the world.

[11] The simple correlation coefficient between PM and PD is 0.997 for the sample period!

Chart 1: Prices, Foreign Costs and the Exchange Rate



Visual inspection of Chart 1 would clearly suggest that the dominant long-run relationship among these four variables is between PM and PD. This in turn is strongly suggestive of a large measure of simultaneity between these two price series[12]. It is easy to see, therefore, how the domestic price variable might dominate in an import price equation, at the expense of the exchange rate and foreign costs, where all four variables are included in the same equation. Such an equation, if estimated, may be mistakenly taken as an indication of incomplete PT[13]. In our view there is likely to be two cointegrating relationships among the four variables: one between PM, ER and CP and another among PD, ER and CP. It is only by estimating such relationships separately that accurate measurements of the degree of exchange rate PT can be

[12] It should in no way, however, be taken to imply price-setting behaviour on the part of Irish importers.

[13] Such an equation, if estimated, may simply represent some weighted average of two separate relationships. This is, of course, the classic identification problem typified in the demand/supply function example where an econometrician who regresses quantity on price does not know whether s/he has estimated a demand or a supply function or simply some average of both.

made[14]. The best methodology for uncovering such long-run cointegrating relationships is, perhaps, the so-called Johansen technique. It is this approach which is adopted in the next section.

5. Econometric Procedure and Results

5.1 Introduction to the Johansen procedure

Given the need to model and take account of the time series properties of the data and our strong *a priori* expectations that there exist two cointegrating vectors among the variables covered, the Johansen cointegration procedure seems to be the most appropriate one to use[15]. If z_t is a *p* x *1* vector of stochastic variables, μ is a constant term and D_t is a vector of nonstochastic variables, such as seasonal or intervention dummies, then the Johansen procedure begins by setting out a model in error-correction form[16] as follows, where Δ is the difference operator:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + ... + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-1} + \mu + \Psi D_t + \varepsilon_t, \quad t = 1, ... , T. \tag{5.1}$$

where:

$$\varepsilon_t \sim \text{Niid}_p (0, \Sigma) \tag{5.2}$$

and where k is the lag length. In our model z_t is comprised of import unit values, PM,

[14] It is interesting to note that, since the variables in Chart 1 are logged, an informal assessment of the likelihood of full pass through can be made on the basis of the chart. If full PT held in the long run then the increases in foreign costs and the exchange rate would add exactly to the increases in both sets of prices. The fact that the exchange rate increases by just under 20 units and foreign costs rise by just over 30 units indicates that the domestic price series should take on a value of approximately 150 at the end of the period if full PT is to hold. The fact that both prices are very close to, but just under, this figure at the end of the period, signals that very close to, but perhaps not full PT held in the case of Ireland during the period under analysis. This is investigated more rigorously in the following section.

[15] A good guide to the Johansen procedure is contained in Hansen and Juselius (1995), where the maximum likelihood estimation technique is briefly explained. Johansen (1988, 1991) and Johansen and Juselius (1990) give a more elaborate (albeit highly technical) description of the estimation technique. An excellent account of the intuition behind the Johansen approach to estimation is contained in Hamilton (1994). Finally, a very good practical guide to the Johansen procedure is contained in Harris (1995).

[16] This allows us to distinguish between stationarity due to linear combinations of non-stationary data and stationarity due to differencing. It is also an important representation in that it allows us to test a variety of interesting economic hypotheses, as we shall see later.

domestic competing prices, PD, the nominal effective exchange rate, ER, and foreign unit labour costs, CP. The data are quarterly and run from 1963:1 to 1995:3[17]. If the data are integrated of order one, hereafter I(1), then the matrix Π has to be of reduced rank, r [18]:

$$\Pi = \alpha\beta' , \tag{5.3}$$

where α and β are p x r matrices and $r < p$. The reduced form model (5.1) and cointegration (5.3) is now given by:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + ... + \Gamma_{k-1} \Delta z_{t-k+1} + \alpha\beta' z_{t-1} + \mu + \Psi D_t + \varepsilon_t, \quad t = 1, ... , T. \tag{5.4}$$

where $\beta' z_t$ are the r long-run cointegration relations and α is the matrix of adjustment coefficients. In order to properly interpret the reduced form model, however, it is necessary to impose certain restrictions on the data which are derived from economic theory. For instance, as we shall see later, one constraint we attempt to impose upon the data is that of full pass-through of the exchange rate (and foreign costs) to import prices in the long run.

5.2 Unit root tests

The first stage of the Johansen procedure involves carrying out unit root tests on the variables of interest[19]. The results of the Dickey-Fuller/Augmented Dickey-Fuller

[17] The data period was chosen on the basis that it was the longest available for the data series in question and, hence, was most appropriate for assessing the degree of PT in Ireland. (Recall the notoriously low power of unit root tests as demonstrated by Froot and Rogoff, 1995, for example, which can be addressed to some extent at least by increasing the span of the data). A number of important structural breaks occurred during this period, such as the break up of Bretton Woods in the early 1970s and Ireland's accession to the European Monetary System in 1979. Such breaks do not seem to have strongly affected the data series, however, as is evidenced in Chart 1. (Indeed, the new lower inflationary environment of the 1980s appears to have had more of an impact on the basis of this chart). Moreover, one would not expect a change in the exchange rate regime to unduly interfere with long-run PT relationships.

[18] If Π was of full rank, this would imply that all variables were I(0). If Π has zero rank the term Πz_{t-1} drops out of the equation and the variables in question are not cointegrated. If 0 < rank of Π < P, there is at least one cointegrating vector. In the absence of I(0) variables, the rank of Π equals the number of stable long-run relationships which exist among the data.

[19] All four variables were logged before the econometric analysis was undertaken.

(DF/ADF) tests and Phillips Perron (PP) tests for a unit root are presented in Tables 1 and 2 below:

Table 1: Unit Root Tests = I (0) V's I (1), I (2)

Variable	Number of Lags#	DF/ADF	PP
PM	1	-0.40	0.11
PD	6	-0.98	0.16
ER	0	-0.95	N/A
CP	1	-0.17	0.44

DF/ADF/PP = Dickey-Fuller, Augmented Dickey Fuller and Phillips Perron tests. A constant and trend is included in all cases.
Critical value at the 5% level = -3.45
* Null of I (1) rejected.
# Number of lags required to achieve white noise in the residuals.

Table 2: Unit Root Tests = I(1) V's I (2)

Variable	Number of Lags#	DF/ADF	PP
Δ PM	0	-6.14*	N/A
Δ PD	5	-2.40	-6.44*
Δ ER	0	-10.43*	N/A
Δ CP	0	-6.36*	N/A

DF/ADF/PP: Dickey-Fuller, Augmented Dickey Fuller and Phillips Perron tests. A constant and trend is included in all cases.
Critical value at the 5% level: -3.45
* Null of I (2) rejected
# Number of lags required to achieve white noise in the residuals

It can be seen from the tables that the results strongly suggest that all the variables are I(1). Although the DF/ADF results suggest that PD may be I(2), the PP test strongly rejects this hypothesis.

5.3 Choice of lag length and rank

Given that the choice of the rank of Π should be made on the basis of a well-specified model, it is important to include the appropriate number of lags before rank tests are undertaken. Accordingly, in the next stage we include the minimum number of lags

which is compatible with well-behaved residuals[20]. This is done on the basis of multivariate Lagrange Multiplier (LM)-type tests for first- and fourth-order autocorrelation and a normality test based on a multivariate version of the univariate Shenton-Bowman test - see Hansen and Juselius (1995) for details. In each case the null hypothesis is one of well-behaved residuals, and hence the lower the test statistic and the higher is the p-value, the more acceptable is the model. The results are reported in Table 3 below.

Although normality of the residuals is rejected for lags 1 to 5, this is primarily driven by the CP equation, as one might expect, given that other explanatory factors not included in our model could perhaps explain foreign unit labour costs more satisfactorily. It is important to note, however, that Cheung and Lai (1993) and Gonzalo (1994) demonstrate the robustness of the Johansen procedure to non-normality of residuals. Perhaps the addition of further dummy variables could have eliminated the normality problem but the robustness of the Johansen procedure to many dummy variables is not known. The performance of the model at lag lengths 4 and 5 is far more satisfactory insofar as the absence of autocorrelation is concerned and, given its superior performance, we opted for a model with a lag length of 5. This implies 4 lags of the first differences of the variables in the vector error correction mechanism (VECM) representation of the data.

Table 3: Choice of Lag Length

	Lags	**First order autocorrelation**		**Fourth order autocorrelation**		**Normality**	
c2 (degrees of freedom). → Combination ¯		**c^2 (16)**	**P-Value**	**c^2 (16)**	**P-Value**	**c^2 (8)**	**P-Value**
PM, PD, ER, CP	1	129.75	0.00	40.44	0.00	41.68	0.00
	2	21.59	0.16	35.28	0.00	21.08	0.01
	3	23.14	0.11	30.74	0.01	26.43	0.00
	4	17.45	0.36	21.41	0.16	41.60	0.00
	5	18.63	0.29	14.08	0.59	35.62	0.00

[20] It was also decided from an examination of the data that dummy variables should be included, where appropriate. Dummies were used where any observation fell outside the mean +/- 3 standard errors range. These dummies are discussed further in the Data Appendix.

The imposition of the appropriate rank of the Π matrix is one of the most important steps of the Johansen analysis. It is critical because all the subsequent results are conditional on the choice made. In this study we employ the widely used maximum eigenvalue (λ_{max}) and trace test statistics, the results of which are reported below in Table 4.

Table 4: *l* max and Trace Tests

Combination ¯	*l* max	90% C.V.	Trace	90% C.V.	H_o= r
PM, PD, ER, CP	32.75*	17.15	53.38*	43.84	0
	9.03	13.39	20.63	26.70	1
	7.00	10.60	11.60	13.31	2
	4.59	2.71	4.59	2.71	3

* H_o rejected at the 10% level

According to the results there is at least one cointegrating vector. Although there does not appear, on the face of it, to be a strong case for a rank of 2, we will proceed on the basis that this is indeed the appropriate rank for a number of reasons. First of all, our strong economic priors, together with evidence presented in Chart 1, suggest the acceptance of two cointegrating vectors instead of a single one. In addition, the fact that the first two unrestricted cointegration relations appear stationary when they are graphed also appears to support this decision (see Charts 2 and 3 below)[21]. Third, Johansen and Juselius (1990) suggest that since the power of their tests is likely to be low for cointegration vectors with roots close to, but outside, the unit circle, we are perhaps further justified on this basis in rejecting the null hypothesis with somewhat higher significance levels than 10%. Fourth, where there exists severe multicollinearity between variables, Hansen and Juselius (1995) have argued that this can lead to the unwarranted insignificance of one of them. Arguing further along these lines, it is easy to envisage a situation where such multicollinearity could lead to the unwarranted

[21] The difference between the upper and lower segments of Charts 2 and 3 is that the top part graphs the actual disequilibrium as a function of all short-run dynamics, whereas the lower part is corrected for such short-run influences. The fact that the second cointegrating vector (see Chart 3) does not appear to be as stationary as the first (Chart 2) is to be expected on the basis of the rank tests. Nevertheless, the fact that the second vector appears to be stationary is encouraging.

exclusion of a cointegrating vector for one of the variables in question[22].

Chart 2: Cointegrating Relationship 1

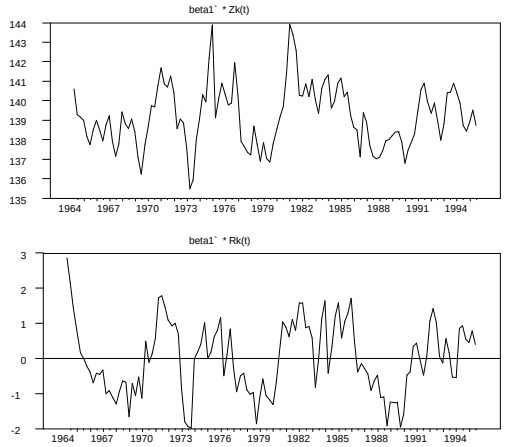
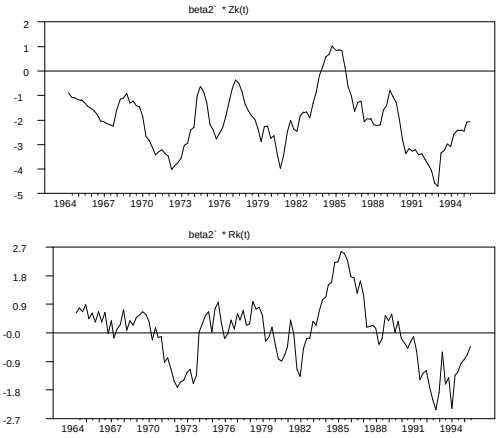


Chart 3: Cointegrating Relationship 2



5.4 Long-run identification/hypothesis testing

Although at this stage it is possible to arrive at estimates of the two stationary β cointegrating vectors after imposing the chosen rank of 2, such vectors are not necessarily meaningful or interesting. The reason is that any linear combination of the stationary vectors is also a stationary vector. This is, of course, the classic identification problem, which must be overcome if we are to reach meaningful conclusions. Johansen and Juselius (1992, 1994) provide a thorough description of the identification issue. Johansen and Juselius (1994) (p. 8) discuss identification on three different levels:

(1) generic identification, which is related to a linear statistical model;
(2) empirical identification, which is related to the estimated parameter values;
(3) economic identification, which is related to the economic interpretability of the estimated coefficients of an empirically identified structure.

[22] Indeed, this is what appears to be the case here. When a rank of 1 is imposed, as Menon's approach would suggest, the following vector is obtained when we normalise upon PD: PD = 0.27 PM + 0.72 ER + 0.62 CP. When normalised upon PM, this vector is not readily interpretable from an economic point of view. Strong multicollinearity may have served to "remove" the PM vector from the rank statistics. Judged instead as a PD equation, it can be seen that it is a type of partial mark-up model for such domestic prices. It can be easily shown, however, that this equation is simply an approximation to a linear combination of the types of pass-through equations obtained for both PM and PD when a rank of 2 is imposed. The fact that no sensible pass-through equation can be obtained for PM (the objective of our study) when a rank of unity is imposed is yet another reason for overriding the results of the λ max and trace rank tests.

In essence, generic identification of the long-run structure entails imposing restrictions on the space occupied by β such that each cointegrating relation is unique. In our case, where there are two equilibrium vectors, the first β vector is identified if no linear combination of the second vector yields a vector that "looks like" the coefficients of the first vector. Thus, the condition for generic identification simply requires that no linear combination of the second vector satisfies the restriction defining the first long-run relation.

After having confirmed that the hypotheses/restrictions tested for are generically identifying we report the results of various hypothesis tests in Table 5 below. As Johansen and Juselius (1992, 1994) argue, the types of hypotheses tested for below give rise to a likelihood ratio test that is asymptotically distributed as χ^2. These tests can be used to check for non-rejection of the restrictions imposed relative to an exactly identified model. The imposition of symmetry for the coefficients of the exchange rate and foreign costs in both the PM and PD vectors (Test 1 in the table), yields quite plausible coefficients of 0.93 and 0.91 respectively which are, furthermore, acceptable with a strong P-value of 0.57. The joint hypothesis, that of full pass-through for both sets of prices (Test 2) is, however, rejected by the data. These findings provide corroboration for our earlier assessment of the likely extent of PT based on the informal analysis of Chart 1.

Table 5: Long-run Hypothesis Test Results

Test		Hypothesis	Test Results[23]	Significance	Estimated long-run relationship
1	Hyp 1	PM = θER+θCP	$\chi^2(2) = 1.17$	##	PM = 0.93 ER + 0.93 CP
	Hyp 2	PD = θER+θCP	P-Value = 0.56		PD = 0.91 ER + 0.91 CP
2	Hyp 1	PM = ER + CP	$\chi^2(4) = 21.72$	Rejected	Not applicable
	Hyp 2	PD = ER+CP	P-Value = 0.00		Not applicable

Joint hypothesis acceptable with a probability value above 0.10
Joint hypothesis acceptable with a probability value above 0.05

[23] These test results illustrate the acceptability of imposing restrictions on the model. The degrees of freedom contained in the χ^2-statistic illustrate the number of restrictions in each vector relative to an exactly identified model.

Finally, it is necessary to assess the dynamics of adjustment to the long-run equilibria contained in Test 1 above. These are presented in Table 6 below. First, the error correction mechanism (ECM) containing PM enters its own equation with a coefficient of -0.10 and a highly significant t-statistic of -3.38. This means that when import prices exceed their long-run relationship with foreign costs and the exchange rate, they adjust downwards at a rate of 10% a quarter (implying a half life of just over one and a half years)[24]. The relatively long period for half-life adjustment demonstrates the importance of incomplete PT in the short run. Similarly, the adjustment coefficient of 0.18 in the third column indicates that when domestic prices are above their long-run equilibrium level, this feeds through positively into import prices. This finding provides some support for the assumption in the mark-up theory that import prices are affected by domestic prices, at least in the short run. As may be expected, domestic prices do not interact as strongly with the ECM's as import prices, which are subject to a much more direct influence from foreign variables. In fact, domestic prices are weakly exogenous with respect to the import price ECM and are only loosely affected by their own long-run relationship with the exchange rate and foreign costs, with a low adjustment of -0.06 and a correspondingly low t-statistic of -1.55. A finding of a stronger statistical relationship in the case of the second ECM would have been welcome, although the fact that a correctly signed long-run equilibrium relationship emerges is comforting. Finally, an exchange rate equation is presented for completeness, in which it is demonstrated that the exchange rate is weakly exogenous with respect to both long-run equilibrium relationships[25].

[24] The interpretation of the adjustment coefficients is partial in the sense that it is assumed that all the movement towards equilibrium is accounted for by the dependant variable alone - no allowance is made for the ways in which the adjustment of the other variables in the system can alter the speed in which equilibrium is reached. The half life measures are calculated as follows: Take PM, whose adjustment coefficient is -0.10. We know that $(1 - 0.10)^n = 0.5$, where n is the number of periods in the half life of deviations of PM from equilibrium. Taking natural logs of both sides of the equation and rearranging gives $n = (\ln 0.5/\ln 0.90) = 6.6$ (quarters). Calculated similarly, the half life of deviations from PD equilibrium is 11.2 quarters.

[25] The system was estimated conditional on foreign unit labour costs, CP, given that endogenising such costs on the other variables would not be sensible. Strictly speaking, it is only when a variable has been found to be weakly exogenous is one justified in conditioning on it. The fact that CP was not found to be weakly exogenous in subsidiary tests (not reported) points towards the possibility that factors which could potentially explain CP have been excluded from our system. Obviously, the inclusion of such factors is not feasible if we are to preserve model parsimony. Accordingly, the original four variable system is retained and CP is treated as exogenous.

Table 6: Adjustment Coefficients in the Parsimonious VAR Representation

Dependant variable	Adjustment Coefficient (ECM1) (t-statistic in brackets)	Adjustment Coefficient (ECM2) (t-statistic in brackets)	Long-run cointegrating vectors
Δ PM	-0.10	0.18	ECM1:
	(-3.38)	(2.62)	(PM - 0.93 ER - 0.93 CP)
Δ PD	0.01	-0.06	
	(0.62)	(-1.55)	
Δ ER	0.01	-0.06	ECM2:
	(0.62)	(-0.69)	(PD - 0.91 ER - 0.91 CP)

5.5 Summary of results and comparison with previous studies

In commenting upon our overall results, we shall first compare them with those of Menon (1995b) who analysed Australian import prices and argued that his results supported less than full PT. Subsequently, the results are contrasted very briefly with the general findings in the PT literature. Finally, we compare our results with a selection of previous Irish studies of relevance.

It was clearly seen in the informal analysis how import and domestic competing prices followed very similar paths in Ireland since 1963. Indeed, we would be somewhat surprised if this was not the case for the majority of SOEs. Relating this finding to the Johansen procedure, it is our view that there should be two cointegrating relationships present using data of this type for a SOE, i.e. one between import prices and both the exchange rate and foreign costs and another between domestic competing prices, the exchange rate and foreign costs. The significance of both ECMs in the import price equation in Table 6 can be seen as vindication of these prior beliefs. Accordingly, any approach which fails to address this issue will be inaccurate and will bias the results away from the possibility of finding full, or close to full, pass-through. We therefore think that Menon's (1995b) finding of incomplete PT for Australian imports may be incorrect and downwardly biased, and a more plausible estimate may be obtained where two cointegrating relationships are allowed for. Indeed, the evidence provided in Menon suggests that a rank of 2 may indeed be appropriate for his data set. The hypothesis that the rank is ≤ 1 in Menon's paper is almost rejected using 5% critical

values, suggesting that a rank of 2 or more would be acceptable using the more widely-used 10% critical values. Although our Johansen results provide less evidence for the presence of multiple cointegrating vectors, a variety of arguments presented earlier favours the acceptance of a rank of 2. This choice seems to be strongly justified on the basis of the hypothesis tests carried out and illustrated in Table 5. This table demonstrates that the types of relationships hypothesised regarding import and domestic prices are strongly congruent with our dataset. Finally, the table yields some evidence that the extent of exchange rate PT is very high[26]. In addition, it appears to be stronger in the import than in the domestic price series[27].

Although full PT cannot be accepted for both sets of prices simultaneously, as pointed out above, the fact that PT seems to hold more strongly for import rather than domestic prices is intuitively pleasing. Briefly contrasting our results with other studies in the international literature, it is interesting that in the Menon (1995a) survey, he finds that significantly incomplete PT is often found to be the case in studies in this area[28]. Our results accord much more closely to the full PT hypothesis. This pattern, may, however, be due to the fact that most previous studies failed to take the time series properties of the data into account and their results may, accordingly, be questionable. Secondly, we have seen how the use of a single import price equation in a mark-up framework (as per Menon) is inappropriate for a SOE, leading to an unwarranted rejection of full, or close to full, PT. The use of a single markup equation containing domestic competing prices for large economies, such as the US, as per Hooper and Mann (1989), Melick (1990) and Swamy and Thurman (1994) may be more appropriate, but any possibility of simultaneity existing between import and domestic competing prices should be investigated as a matter of course[29].

[26] It should be stressed that the paper argues that PT is very high for aggregate Irish imports. No inference should, therefore, be made regarding the extent of PT in individual industries on the basis of these results.
[27] This can be seen from the coefficients in the ECM which are closer to unity and the half-life of deviations from equilibrium which is far shorter in the case of import prices.
[28] This is found to be the case, whether analysing aggregate traded prices or disaggregated data. It is easier to envisage incomplete PT occuring at an individual industry level than at the broad macro level, where equilibrating mechanisms leading to full PT in the long run are more likely to hold.
[29] As previous researchers on PT in large economies have demonstrated, it is also important in such circumstances to check for the possibility of the domestic exchange rate (er) affecting the foreign cost structure (cp).

The only previous paper of direct relevance to import price PT for Ireland is Browne (1983) who finds that the price-taking hypothesis cannot be rejected for imports. Although weaker evidence is provided on Irish exports, in a previous paper, Browne (1982) strongly supports the price-taking hypothesis for Irish exporters also. On a broader, though somewhat related, front, Flynn (1986) and Honohan and Flynn (1986) find that exchange rate changes are fully reflected in domestic (import and consumer) prices in the long run. In contrast, O'Connell and Frain (1989) find that only 50% of an exchange rate change is reflected in domestic (consumer) prices. Certain parallels can also be drawn between our macroeconomic approach to the PT question for Ireland and the various purchasing power parity (PPP) papers which preceded it. If far from complete PT was found to hold this could, perhaps, be interpreted as providing indirect backing for those who question the validity of PPP as a workable proposition for Ireland. Earlier evidence on the validity of PPP for Ireland is mixed and is reviewed in Kenny and McGettigan (1996). It is important to note, however, that most of the above papers make use of relatively short data sets and concentrate on consumer rather than traded prices. The half life of deviations from consumer price-based PPP is likely to be rather long and may need a very long data set to uncover the true underlying relationship. Given the short span of data sets typically employed in previous Irish studies it is, perhaps, surprising that any support is found for the existence of PPP. This paper differs from most of the earlier studies in that it employs a model specifically designed to measure the extent of PT in an economy and makes use of a relatively long data set, covering the 1963 to 1995 period.

6. Summary and Conclusions

This paper employs the Menon (1995b) variant of the mark-up model to assess the extent of exchange rate pass-through (PT) in the case of Irish import prices. In doing so, it argues that in order to measure PT accurately, account must be taken of the high degree of simultaneity that exists between import prices and competing domestic prices, especially for small open economies such as Ireland[30]. This paper does this by employing the Johansen cointegration technique and estimating separate equilibrium

[30] This strong simultaneity is demonstrated clearly in the informal analysis presented in section 4 of the paper.

relationships for both sets of prices. In doing so, it uncovers strong evidence of close to full PT for both Irish import and domestic competing prices. This contrasts strongly with Menon (1995b) who finds substantially less than full PT for the case of Australia, another small open economy. We would argue that the difference in the two sets of results may be driven by the fact that Menon does not explicitly take account of the simultaneity that exists between both sets of prices, and, accordingly, mistakenly allows for only a single long-run equilibrium relationship[31]. Finally, our results suggest that any deviations from long-run equilibrium take some time to be restored for import prices and, hence, support the notion of incomplete PT in the short run.

[31] Our findings also cast doubt upon the strong policy conclusions drawn by Menon (1993b, 1995) regarding the effects of exchange rate changes, based upon his findings of incomplete PT. We would argue, unlike Menon, that the assumption of international price-taking behaviour for imports is likely to be a close enough approximation for most SOEs. In this paper we have provided some support for this argument by demonstrating that very close to full PT held for Ireland over the last 30 years or so.

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Data Appendix

Description of Data

PM: Import unit values. *Source*: International Financial Statistics (IFS), International Monetary Fund, CD ROM databank.

ER: Nominal import-weighted effective exchange rate (a specially constructed index). *Sources*: Import shares obtained from Central Statistics Office, Trade Statistics, various editions. Three import shares were obtained, i.e. those for the United Kingdom, those for Germany (taken to represent other European trade) and those for the United States (taken to represent trade with the rest of the world). The nominal bilateral exchange rates were obtained from the IFS, CD ROM databank.

PD: Domestic manufacturing output price index. *Source*: IFS, CD ROM databank.

CP: Import-weighted foreign unit labour cost index. *Source*: Weights were obtained as in the construction of the nominal effective exchange rate above. Unit labour costs in the UK, Germany and the US were obtained from the IFS, CD ROM databank.

Dummy variables: In order to exclude outliers from the analysis, it was decided to insert dummies where the first difference of the logged variables fell outside the Mean +/- 3 Standard Errors range. The dummies created were as follows:

• Δ PM	1974:1	(Economic rationale: The first oil shock).
• Δ EER	1967:4	(Devaluation of sterling against the dollar).
	1993:1	(Recent ERM devaluation)
• Δ PD	1975:1	(Delayed reaction to the first oil shock)
• Δ ULC	1967:4	
	1983:1	
	1993:1	