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CENTRE of POLICY STUDIES and the IMPACT PROJECT

Exchange Rate Pass-through: Theory and Evidence

by

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The Centre of Policy Studies (COPS) is a research centre at Monash University devoted to quantitative analysis of issues relevant to Australian economic policy. The Impact Project is a cooperative venture between the Australian Federal Government and Monash University, La Trobe University, and the Australian National University. During the three years January 1993 to December 1995 COPS and Impact will operate as a single unit at Monash University with the task of constructing a new economy-wide policy model to be known as MONASH. This initiative is supported by the Industry Commission on behalf of the Commonwealth Government, and by several other sponsors. The views expressed herein do not necessarily represent those of any sponsor or government.

ABSTRACT

The resilience of trade balances of the major industrialised economies to changes in their exchange rates has evoked interest in the exchange rate pass-through relationship. So far, there has not been a comprehensive survey of this literature. The paper aims to fill this gap in two ways. First, it pieces together the theoretical literature on exchange rate pass-through. Second, it provides a critical survey of the empirical literature on exchange rate pass-through. Emphasis is placed on the data and methodology employed in previous work. This is done in order to guide future work in this growing area of research.

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CONTENTS

| | |
|--|----|
| 1. Introduction | 1 |
| 2. Exchange Rate Pass-through: Theory | 3 |
| 2.1 Exchange Rate Pass-through: The Elasticities Approach | 3 |
| 2.2 Market Structure and Product Characteristics | 4 |
| 2.2.1 Perfect Competition and Product Homogeneity | 4 |
| 2.2.2 Imperfect Competition and Product Differentiation | 5 |
| 2.3 Multinational Corporations (MNCs) and Intra-Firm Trade | 11 |
| 2.4 Non-Tariff Barriers (NTBs) | 13 |
| 3. Exchange Rate Pass-through: Evidence | 15 |
| 3.1 Salient Features of Previous Studies | 33 |
| 3.1.1 Country-Coverage | 33 |
| 3.1.2 Data | 33 |
| 3.1.3 Methodology | 36 |
| 3.1.4 Findings | 37 |
| 3.1.4.1 Pass-through: Degree and Dynamics | 37 |
| 3.1.4.2 Pass-through Across Countries | 38 |
| 3.1.4.3 Pass-through Across Studies for a Given Country | 38 |
| 3.1.4.4 Pass-through Across Products | 39 |
| 3.1.4.5 Stability of the Pass-through Relationship | 40 |
| 4. Summary | 40 |
| Tables | |
| 1. The Empirical Literature: A Summary of Data, Methodology & Findings | 16 |
| 2. Number of Estimates of Pass-through by Country | 34 |
| Figure | |
| 1. Exchange Rate Pass-through in the Presence of Quantitative Restrictions | 14 |

Prices Surveillance Authority (PSA) (1989) Inquiry into effects of exchange rate appreciation on prices of consumer goods. *Report No. 21*, Canberra: Australian Government Publishing Service (AGPS).

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Exchange Rate Pass-through:

Theory and Evidence¹

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1. Introduction

The debate over fixed versus flexible exchange rates is one of the longest running sagas in the international economics literature. The case for flexible exchange rates, as it was initially and forcefully put by Friedman (1953) and Johnson (1969), had as one of its pillars the claim that it would provide for a more efficient system of international adjustment. In this context, the advent of floating exchange rates after the breakdown of the Bretton Woods system was greeted with enthusiasm, as it was felt that currencies had moved way out of line from their equilibrium rates during the Bretton Woods era. Under the floating exchange rate regimes, foreign exchange markets around the world have been characterised by a considerable amount of variability. However, the initial enthusiasm about the expected equilibrating role of floating exchange rates began to wane as the trade balances of major trading nations continued to show remarkable resilience to such changes.

This has led to a frantic search for explanations to account for this "adjustment puzzle". The conventional explanations couched in terms of elasticity pessimism have little to offer in resolving this issue; there is now a vast empirical literature that has convincingly established the case that Marshall-Lerner conditions are easily satisfied in most countries². In this context, a number of authors have been motivated to step back and examine more closely the underlying relationship between exchange rates and prices of internationally traded goods, now popularly known as the exchange rate pass-through relationship³. Exchange rate pass-through refers to the degree to which

(1) I would like to thank Premachandra Athukorala, Peter Dixon and Donald George for comments on the paper without implicating them in any way.

(2) For useful surveys of this literature, see Magee (1975) and Goldstein and Khan (1985).

(3) In this paper, the terms "exchange rate pass-through" and "pass-through" are used interchangeably.

exchange rate changes are reflected in the destination currency prices of traded goods.

The reason for the inability of even the "elasticity optimists" to account for the sluggishness of trade flows to exchange rate changes may lie with the fact that they assume that exchange rate changes are fully passed-through to prices of traded goods. If exchange rate changes are not fully or substantially reflected in the selling prices of traded goods, then the anticipated quantity adjustment will be retarded even if the degree of demand elasticity is sufficiently large. In other words, a low pass-through would make it possible for trade flows to remain relatively insensitive to exchange rate changes, despite demand being highly elastic. Furthermore, if significant lags exist in the transmission of exchange rate changes to prices, coupled with the subsequent lag in the quantity-response to the relative price change, then the overall balance of payments adjustment process could be severely retarded⁴.

Given the importance of the pass-through issue, a sizeable literature has developed over recent years. So far, there has not been a comprehensive survey of this literature. The paper aims to fill this gap in two ways. First, it pieces together the theoretical literature on exchange rate pass-through. This is the subject of Section 2. We begin by discussing early approaches to measuring pass-through based on trade elasticities. We then proceed to consider more recent developments that emphasise market structure and product characteristics, intra-firm pricing practices of multinational corporations (MNCs), and the effects of non-tariff barriers (NTBs) on traded goods prices following exchange rate changes⁵. Second, it provides a critical survey of the existing empirical literature on pass-through. This is the subject of section 3. Emphasis is placed on the data and methodology employed in previous work in this area. A final section presents a summary of major points, and suggests directions that future research should take.

(4) A chronological taxonomy of the behaviour of prices of internationally traded goods following a depreciation is provided in Magee (1973) and Branson (1972). Magee (1973) highlights the initial phase as the "currency contract" period, in which capital gains or losses on outstanding contracts are observed. Following this, a "pass-through" period is observed, in which prices respond to the new exchange rate but quantities of trade are not yet affected. Finally, a "quantity adjustment" period completes the process, in which quantities and prices move towards a new equilibrium. The trade balance can move in almost any direction in each of these subperiods, and the duration of the lags that are involved in the second and the third phase will undoubtedly bear significantly on the overall outcome of the adjustment process.

(5) The discussion is organised so that the different factors that affect the relationship between exchange rates and prices are treated separately. This approach is necessitated by the fact that "there is no single coherent theory of devaluation (or revaluation) under imperfect competition, but rather an amalgam of reasons why prices may not respond fully to exchange rate changes" (Magee 1975, p.231).

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2. Exchange Rate Pass-through: Theory

2.1 Exchange Rate Pass-through: The Elasticities Approach

Initial interest in the pass-through relationship developed as a consequence of empirical work involved in the estimation of import and export demand and supply elasticities in international trade. The relationship between the exchange rate and traded goods prices can be derived using these elasticities. Consider the following demand and supply functions for an imported good:

$$Q_D = D(P_D) \quad (1)$$

$$Q_S = S(P_F / ER) \quad (2)$$

where Q_D and Q_S represent the quantity demanded and supplied of the imported good, P_D and P_F represent the domestic and foreign currency price of the imported good, and ER represents the exchange rate (the foreign currency price of domestic currency).

Differentiating (1) and (2), we have:

$$\partial Q_D = (\partial D / \partial P_D) \partial P_D \quad (3)$$

$$\partial Q_S = \partial S / \partial P_F \{ (1/ER) \partial P_D - (P_D / ER^2) \partial ER \} \quad (4)$$

Setting (3) and (4) equal to each other in equilibrium, and denoting the elasticity of demand as $\epsilon_D = (\partial D / \partial P_D) P_D / Q_D$ and the elasticity of supply as $\epsilon_S = (\partial S / \partial P_F) P_D (ER / P_D)$, we have:

$$(ER Q_D / P_D) / \epsilon_S \{ (1/ER) \partial P_D - (P_D / ER^2) \partial ER \} = Q_D / P_D \epsilon_D \partial P_D \quad (5)$$

which simplifies to:

$$(\partial P_D / P_D) / (\partial ER / ER) = (1 - \epsilon_D / \epsilon_S)^{-1} \quad (6)$$

Equation 6 shows that the percentage change in the domestic currency price of the imported good following an exchange rate change is a function of the elasticities of demand and supply. Based on this formula, it is clear that if the supply or demand for imports is perfectly elastic (inelastic), then pass-through is going to be complete (zero). Studies that employed this formula to measure pass-through focussed mainly

on the aggregate outcome for individual countries. For instance, Branson (1972) was able to show how changes in the exchange rates of large economies such as the US could alter world prices, thus ensuring the co-existence of less than full pass-through with the preservation of the law of one price. The general conclusion of these studies points to the larger less-open countries experiencing much lower pass-through than the smaller more-open economies (Kreinin, 1977; Spitaeller, 1980; for details, see Table 1).

There are a number of problems associated with the measurement of pass-through based solely on elasticities of demand and supply. First, this approach does not provide any information on the *timing* of the response of prices to exchange rate changes. Second, it ignores what lies behind the supply responses of producers in different countries (Venables, 1990). The supply response will depend on the details of the industrial organisation and of the technology of the industry under study. Recent developments in the literature on imperfect competition and trade address both these issues, and it is to these developments that we turn to next.

2.2 Market Structure and Product Characteristics

The theoretical explanations of incomplete pass-through have emphasised the role of market structure first, followed by product differentiation. These authors have been concerned to explain whether the empirical data on pass-through merely reflects short-run squeezing of profit margins by exporters, or if particular types of market organisation always lead to only a limited response of prices to exchange rate changes.

2.2.1 Perfect Competition and Product Homogeneity

In order to analyse the role of market structure and product characteristics in determining the pass-through relationship, it is useful to start with the case of a perfectly competitive market where the imported and the domestically produced good are perfect substitutes for each other. This case is important not only as a backdrop, but also to clarify the differences that exist under conditions of imperfect competition and product differentiation.

We represent the domestic demand for the domestic and imported good as $D(P)$, the supply of the domestic good as $S_D(P)$, and the supply of the imported good as $S_M(P/ER)$, where ER is the exchange rate (the foreign currency price of domestic currency). At market equilibrium, we have:

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$$D(P) = S_D(P) + S_M(P/ER) \quad (7)$$

Totally differentiating (7), and after rearranging terms, we have the formula for pass-through:

$$\partial P/\partial ER = \epsilon_S^M \alpha / \{ \epsilon_D + \epsilon_S^D (1 - \alpha) + \epsilon_S^M \alpha \} \quad (8)$$

where $\epsilon_D = -D'P/D$ = elasticity of domestic demand; $\epsilon_S^D = S'_D P/S_D$ = elasticity of supply of the domestic good; $\epsilon_S^M = S'_M P/(ER S_M)$ = elasticity of supply of the imported good; α = market share of the import.

Equation (8) highlights the importance of the elasticities of demand and supply in determining the price response to an exchange rate change in a perfectly competitive market. Under these conditions, the measurement of pass-through is similar to that using the elasticities approach discussed in Section 2.2. These elasticities also play a central role in determining the magnitude of the change in import volume following an exchange rate variation. Differentiating $S_M(P/ER)$, and using (8) above, we can express the proportionate change in imports as:

$$\partial S_M = \partial P \{ \epsilon_D + (1 - \alpha) \epsilon_S^D \} / \alpha \quad (9)$$

The change in imports following an exchange rate change will be greater the larger is the elasticity of foreign supply, ϵ_S^M , since this will result in a larger proportionate change in price (∂P), and the larger are the elasticities of domestic demand, ϵ_D , and domestic supply, ϵ_S^D .

2.2.2 Imperfect Competition and Product Differentiation

Under conditions of imperfect competition, pricing will no longer be at marginal cost, and firms would be in a position to charge a mark-up on costs to earn above normal profits even in the long run. The important issue that needs to be addressed in the context of imperfect competition relates to how this mark-up over marginal cost might vary in response to an exchange rate change. Two factors come to mind almost immediately: (i) the degree of substitutability between the domestic and imported good, as determined by the degree of product differentiation, and (ii) the degree of market integration or separation. Both these factors can be viewed as forces that come into play to determine the price-setting power of firms, and will affect the leverage available to them in responding to exchange rate changes. The lower the degree of substitutability between these goods, and the lower the degree of market integration,

the greater will be the market power of sellers.

Dornbusch (1987) considers the Dixit-Stiglitz (1977) model and Salop's (1979) model of competition on a circle to capture the effect of imperfect substitutability and product differentiation on the price response to exchange rate changes. He finds that the degree of pass-through is directly related to the degree of substitutability between the domestic and imported good. Fischer (1989a) considers the case where firms are Bertrand competitors (or Nash price setters) and where foreign firms produce for both the home and export market, but do not practice price discrimination. He finds that if markets are segmented so that arbitrage is limited, an appreciation will lead to a higher pass-through if the domestic market is monopolistic relative to the foreign market.

Manufactured goods are typically viewed as being highly differentiated and frequently sold in imperfectly competitive and segmented markets where arbitrage is costly, and mostly unprofitable. There is a considerable amount of empirical evidence to support both these views about manufactured goods. First, there is the large number of empirical studies that points to the failure of the law of one price for manufactured goods at the most disaggregated level for which data are available. These studies can be divided into the following two categories, which we will call Test 1 and Test 2 of the law of one price: (i) Test 1 of the law of one price compares the price of imports and domestic-competing goods sold in the domestic market, and (ii) Test 2 compares the price of the domestic good sold on the domestic and the export market, or in two different export markets.

Test 1 is designed to capture the effect of imperfect substitutability between goods produced by different countries but sold in the *one market* as an independent cause of violation of the law of one price. Test 2 focuses on the good produced in one country but sold in different markets. Violation of Test 2 would be attributable to segmented markets which prevent differences in price of the *same good* from being arbitrated away. Examples of violation of Test 1 are Isard (1977), Kravis and Lipsey (1978), and Richardson (1978). Examples of violation of Test 2 are Ohno (1989), Knetter (1989), Marston (1990), and Kasa (1992) (see Table 1). The results from these studies overwhelmingly support the view that there are significant and non-transitory differences in prices following exchange rate changes, as a result of either imperfect substitution between goods or the presence of segmented markets.

Second, the pervasiveness of intra-industry trade in manufactures and the failure to observe *either* the domestic or the foreign good capturing the whole market (when

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produced under constant or decreasing costs) lends further support to the view that domestic and foreign manufactured goods are imperfect substitutes (see, for instance, Greenaway and Milner, 1986; Goldstein and Khan, 1985).

Apart from imperfect substitutability and segmented markets, a number of recent studies have examined how different market structures, and different assumptions about the behaviour of firms will affect pass-through. Dornbusch (1987) considers the case of a Cournot industry with a linear demand curve and constant costs and shows that the degree of pass-through is positively related to the ratio of the number of foreign firms to total firms and on the total number of firms. Sibert (1992) extends this aspect of Dornbusch's (1987) analysis and examines the effects that different degrees of collusion and market shares of foreign firms have on pass-through. Sibert finds that Dornbusch's result that pass-through is increasing in the number of foreign firms generalises to a variety of behavioural assumptions.

Let us consider the case of the Cournot oligopoly model in some detail. The Cournot case is useful not only because it is probably the most widely accepted benchmark, but also because this formulation concentrates on features of the market structure in explaining the price response by assuming perfect substitutability between the domestic and imported good. The analysis is based on Dornbusch (1987) and Venables (1990).

Suppose that there are n^D domestic firms, all of which are identical, and n^F foreign firms, all of which are identical to each other, but not to the domestic firms. In a Cournot setting, we assume that each firm chooses its sales in the domestic market given the sales of the other firms, and then price is determined from the demand curve.

The profits of the n^D domestic firms are given by:

$$\pi^D = Px^D - C^D(x)^D \quad (10)$$

and for the n^F foreign firms:

$$\pi^F = Px^F - ER C^F x^F \quad (11)$$

where x^D and x^F are the outputs of the domestic and the foreign firms, and $C^D(x^D)$ is the cost function of domestic firms. For simplicity, we assume that marginal cost of foreign firms, C^F , is constant in their currency.

We can write the inverse demand function as $P(X)$, where $X = n^D x^D + n^F x^F$.

Profit maximisation by each firm, given the output of the other firms, yields the following first-order conditions for the domestic and foreign firms:

$$P \{1 - x^D / (\epsilon_D X)\} = C^D \quad (12)$$

$$\text{and } P \{1 - x^F / (\epsilon_F X)\} = ER C^F \quad (13)$$

By denoting the market shares of each individual domestic and foreign firm as β^D and β^F , we can re-write equations (12) and (13) in the following way. The necessary conditions for profit maximisation for each of the n^D domestic firms are:

$$P (1 - \beta^D / \epsilon_D) = C^D \quad (14)$$

and for each of the n^F foreign firms:

$$P (1 - \beta^F / \epsilon_F) = ER C^F \quad (15)$$

where C^D and C^F represent the marginal cost of domestic and foreign firms, respectively.

From equations (14) and (15), we can see that the firm's mark-up on marginal cost in determining its price is an increasing function of its market share. This outcome is easily seen for the extreme cases of pure monopoly and perfect competition, where β is 1 and close to 0, respectively.

In order to determine the equilibrium price in the market, we add up the n^D equations (equation 14) plus the n^F equations (equation 15), noting that the sum of market shares equals one, i.e., $n^D \beta^D + n^F \beta^F = 1$.

The equilibrium price in the market is then given by:

$$P = \epsilon_D \{n^D C^D + n^F ER C^F\} / \{\epsilon_D (n^F + n^D) - 1\} \quad (16)$$

Equation (16) states that the market price depends on the sum of marginal costs (in domestic currency terms) of all firms in the market. Since a change in the exchange rate, ER , affects only the n^F foreign firms, it is clear that there will be less than 100 per cent pass-through.

stationary. All in all, the significant differences in the estimate of pass-through obtained by different researchers studying the same country, commodity and time period highlight the importance of choice of data and methodology.

industry differences in pass-through. Kreinin *et al* (1987) and Phillips (1988) attempt to explain inter-industry differences in import price pass-through. Fischer (1989b) examines export price pass-through, and Feinberg (1987, 1989, 1991) looks at pass-through to domestic prices. It would appear that most of these studies find relatively weak support for industrial organisation variables in explaining inter-industry differences in pass-through.

3.1.4.5 Stability of the Pass-through Relationship

A number of studies examine the stability of the pass-through coefficient over time. These include Mastropasqua and Vona (1988), Baldwin (1988), Klein and Murphy (1988), Moffet (1988), Lattimore (1988), Ohno (1989), Kim (1991), Yang (1991) and Athukorala and Menon (1993). Of these studies, only Lattimore (1988), Moffet (1988) and Athukorala and Menon (1993) find that the pass-through relationship has remained stable throughout the period of study. Mastropasqua and Vona (1988) attribute the structural break identified in their study in May 1982 to the increase in the imposition of NTBs to trade, thus distorting the historical pass-through relationship. Most of the other studies interpret the structural break as evidence of a "hysteresis" effect in import pricing. A number of studies also test for possible asymmetries in pass-through during periods of depreciation and appreciation of the exchange rate. The studies that find such an asymmetry are Mann (1986), Kreinin *et al* (1987), Lattimore (1988) and Marston (1990), where as Moffet (1989), Lawrence (1990) and Athukorala (1991) find no such evidence.

4. Summary

This paper has pieced together the theory underlying exchange rate pass-through, and provided a critical review of the empirical literature on exchange rate pass-through. The survey of the empirical literature uncovered a number of interesting features relating to the country-coverage, data, methodology and findings of previous work. Fresh research in this area should pay particular attention to the following issues. First, the imbalance in the country-sample needs to be addressed: the experience of the small open economies has received very little attention in the literature. The second lesson relates to data. The common resort to price proxies such as unit values and the lack of studies that use data disaggregated at the product level are particularly worrying. Third, most studies have employed conventional econometric estimation techniques without paying attention to the time-series properties of the data. This is problematic because most of the data used to estimate pass-through are usually non-

To see how the number of domestic firms relative to foreign firms will affect the degree of pass-through, assume that marginal costs are constant, and that foreign and domestic marginal costs are equal. Pass-through is now given by:

$$\partial P / \partial ER = n^F / (n^F + n^D) \quad (17)$$

From equation (17), it is shown that the degree of pass-through is a decreasing function of the ratio of domestic to foreign firms. We can see, for instance, that an equal number of domestic and foreign firms will result in a pass-through of 50 per cent, where as pass-through will fall to 33 per cent if there are twice as many domestic firms as there are foreign firms.

To see how the total number of firms in the market will affect pass-through, we go back to equations (12) and (13), totally differentiating the equilibrium around a point where $C^D = ER C^F$. Making the assumption that ϵ_D is constant, we can now write the formula for pass-through as:

$$\partial P / \partial ER = \{ \sigma^N N ER C^F / (N (1 - \sigma^D) C^D + \sigma^F ER C^F) \} \quad (18)$$

where $N = n^F + n^D$ = total number of firms, and $\sigma^F = n^F / N$ = share of foreign firms in the market.

From equation (18), we can see that $\partial P / \partial ER$ is strictly increasing in N , and as N approaches infinity, $\partial P / \partial ER$ approaches 1. We can also see that if $\epsilon^D =$ infinity, then equation (18) simply reduces to equation (17) above.

More recent innovations have extended the oligopoly pricing literature as it relates to exchange rates by focusing on other ways of incorporating international competitive pressures into the determination of the optimal price. Froot and Klemperer (1989) examine pricing strategies that aim to protect market shares, and how temporary versus permanent exchange rate changes come to bear on this decision. This is done by employing a simple two-period model where market share in the first period will affect the price response to an appreciation in the second period. An important aspect of this paper is that the results do not hinge on the type of competition assumed (Cournot or Bertrand), the functional form of the demand curve, the number of periods or the reasons why market share matters.

They show that while the price response to a temporary appreciation could go either way (i.e., firms could either increase or decrease prices), an appreciation viewed as

permanent leads to foreign firms pricing very aggressively in the host country market in order to gain an increase in market share. This occurs because future market shares depend on current market shares, and any increase obtained from exploiting the appreciation will be of a relatively permanent nature.

The approach that emphasises dynamic and inter-temporal behaviour also underlies the more recent "hysteresis" models of pricing (Baldwin, 1988; Krugman, 1989; Dixit, 1989). The hysteresis models build on the notion of irretrievable sunk costs associated with entry-exit decisions in world markets. It is based on the idea that the volatile climate of floating exchange rates has induced firms to adopt a "wait and see" approach. These models show that firms are less likely to enter a market following a "temporary" and/or "small" exchange rate change if there are significant sunk costs involved. These costs may include the establishment of a distribution and after-sales network, and the building-up of reputation. The entry decision will be hindered further if consumers show brand loyalty, thus lowering the prospects of earning sufficient initial profits to justify the entry decision.

Firms will also be deterred from leaving the market under these conditions, and may continue to service the market despite not being able to cover variable costs. Apart from losing the investment in reputation and other sunk costs, these firms may also consider the additional costs of re-entry in the future, especially if the exchange rate change is short-lived.

The hysteresis effect suggests that competition in the market will remain unchanged as long as exchange rate changes fluctuate within a set band, and that this band will be greater the higher the costs associated with entry and exit. This will result in a lower rate of pass-through, as firms fight to either stay in the market or deter entry. If the exchange rate moves outside this band, however, then entry and exit decisions will follow that permanently alter the structure of the market. That is, the new firms that have entered the market will not leave easily either, and the firms that have left may never re-enter. This may produce a structural break in the observed pass-through relationship, as the new competitive structure of the market may not be consistent with the historical rate of pass-through.

Apart from Kim (1991), who estimates a VAR after detrending the variables, the rest of the studies employ conventional OLS. Of the studies using OLS, Helkie and Hooper (1988) and Hooper and Mann (1989) employ a serial correlation correction mechanism, while the others do not. The way in which dynamics are modelled also varies between these studies. The majority employ polynomial distributed lags, but impose different orders on the shape of the polynomial. Some of the studies enter the lags unconstrained, while others impose constraints and at different points (see Table 1). The most common is the tail constraint, which has the effect of forcing neighbouring lag weights to come close to zero, thus distorting both the lag structure and the cumulative pass-through estimate.

Hooper and Mann (1989) and Meade (1991) employ a foreign cost of production variable in their model, while the rest of the studies use a "world" price variable. Constructed as a weighted average of export unit values or export prices of the import supplying countries. While Hooper and Mann (1989) construct the foreign cost of production variable as an input-output weighted index of foreign labor and material costs, Meade (1991) uses a trade-weighted index of foreign consumer prices. With respect to import prices, Klein and Murphy (1988) use unit values, Meade (1991) uses a variable-weight import price index, and the rest use a fixed-weight import price index.

All in all, the differences in the estimate of pass-through obtained by these researchers who study the same country, commodity and time period point to the sensitivity of the results to the choice of data and the methodology employed.

3.1.4.4 Pass-through Across Products

For the studies that have employed a disaggregated approach, we find that pass-through tends to vary quite significantly across industries or product categories. Studies that examine the pricing to market phenomenon find that not only is pass-through generally incomplete, but the degree of pass-through tends to vary across export markets. They suggest that firms price discriminate across export markets by varying the degree of pass-through of exchange rate changes. These studies include Kim (1990) and Kasa (1992). Studies such as Ohno (1989), Schembri (1989) and Marston (1990) find that firms price discriminate between the domestic and export market by limiting the pass-through of exchange rate changes to export prices in foreign currency.

Only a small number of the disaggregated studies attempt to formally explain inter-

Baxter (1984), Helkie and Hooper (1988), Citrin (1989), Lawrence (1990) and Clark Leith (1990). Not only are exchange rate changes never fully reflected in prices in the majority of studies, but the lags corresponding to the partial pass-through process are quite extensive. The small number of studies that do find full pass-through generally point to even longer lags in the transmission of exchange rate changes to prices. For instance, Helkie and Hooper (1988) find that lags associated with import price pass-through extend to 8 quarters, while Clark Leith (1990) reports lags extending to 5 quarters. The only exceptions are the Australian studies, that find that the lags rarely extend beyond one or two quarters.

3.1.4.2 Pass-through Across Countries

There are significant differences in the rate of pass-through across countries. This is clear from the multi-country studies in particular. Kreinin (1977), for instance, finds that pass-through ranges from a low of 50 percent for the US to full pass-through for Italy. The results from the multi-country studies provide conflicting signals regarding the ability to generalise about the degree of pass-through based on the size and openness of the country. Kreinin (1977) finds that pass-through tends to vary inversely with the size of the country. Khosla and Teranishi (1989), on the other hand, find that pass-through is almost complete for the larger economies such as the US and Japan, but very low for the smaller economies such as Indonesia and the Philippines. Spitaeller (1980) finds pass-through to be complete for the US but not Germany.

3.1.4.3 Pass-through Across Studies for a Given Country

There are also significant differences in estimates of pass-through reported in different studies for a given country. The US is the best example of this, since it is by far the most thoroughly studied country. There are 7 studies that estimate the aggregate pass-through of exchange rate changes to import prices covering roughly the same period, starting from around 1970 and ending between 1986-88 (see Table 1). The estimates range from a low of 48.7 percent reported by Alterman (1991) to a high of 91 percent reported by Helkie and Hooper (1988). The mean value for pass-through for this sample is 69.9 percent, with a standard deviation of 17.5. Given that there is little difference between these studies in terms of commodity or time coverage, the diversity in pass-through estimates would seem to stem primarily from differences in methodology, model specification and variable construction.

2.3 Multinational Corporations (MNCs) and Intra-Firm Trade

The massive instability in foreign exchange markets, and in particular the large exchange rate movements which have come to characterise floating exchange rates, have induced MNCs to actively employ intra-firm pricing policies which prevent or at least stagger the full transmission of exchange rate changes to selling prices in individual markets. This practice has facilitated the stabilisation of prices in domestic markets, and allowed subsidiaries of MNCs to avoid significant loss of market share following large exchange rate depreciations. Based on a survey-study of the pricing behaviour of UK firms following devaluation, Holmes (1978, p.118) reports that "the existence of a directly owned sales subsidiary appeared to be a helpful factor in enabling the firm to base its prices more accurately on what the market would bear. ... There was in fact a tendency for firms using their own subsidiaries for sales activities to hold prices in foreign currency". Dunn (1970) provides anecdotal evidence of MNCs employing their sales subsidiaries to facilitate similar pricing strategies in Canada.

There exists a number of ways in which MNCs can shield themselves against exchange rates uncertainty, or large and unfavourable exchange rate shocks. One of the most common and straight forward methods involves the use of internal or intra-corporate exchange rates that apply to intra-firm transactions⁶. These exchange rates may vary significantly from the external or true exchange rate for prolonged periods, since they serve merely as a *clearing mechanism* for intra-firm trade. The use of these internal exchange rates by MNCs in order to achieve global profit-maximising objectives has long been recognised in the literature. In the past, they have been used to protect intra-corporate debtors against the full valuation effects of major exchange rate fluctuations (Helleiner, 1985), and to allocate funds between subsidiaries of the MNC in line with its international liquidity policy (Grassman, 1973). These exchange rates can also be manipulated to reflect global decisions relating to pricing and the absorption of exchange rate movements. Evidence supplied to the Prices Surveillance Authority (PSA, 1989) suggests that the use of intra-corporate exchange rates is widespread among MNCs operating in Australia, and that its use is designed primarily to guard against unfavourable price consequences of large exchange rate movements. They further note that the widespread use of these internal exchange rates have severely weakened the link between exchange rates and import prices.

(6) Intra-firm trade refers to transactions that occur between a parent firm and its wholly-owned subsidiary or majority-owned affiliate, or between two subsidiary or affiliated firms.

Unlike arms length transactions, intra-firm trade is susceptible to the manipulation of the timing of payment on purchases from subsidiaries to coincide with more favourable exchange rates. As Grassman (1973, p.105) puts it, "the observation of certain definite payments conditions is of minor consequence within (MNCs), which therefore choose the freest and least-specific form of payment. We have found that there is considerable scope for payment adjustments in the internal transactions of multinational firms. ... There is generally more room to manoeuvre". The leverage available to the MNC to determine the timing of payment on contracts through flexible internal credit arrangements would enhance the ability of subsidiaries to price to the market independently of current exchange rates.

For instance, a subsidiary would be in a much better position to continue to sell at pre-depreciation prices, in order to preserve market share, if it had the cooperation of the overseas supplier to defer payment until such time in the future when the currency recovers. Carse *et al* (1980, p.93) find that such flexible methods of settlement are almost solely to be found in the case of intra-MNC trade, with credit terms twice as long or longer than for independent firms. They conclude that the degree to which such arrangements are exploited depend almost exclusively on the circumstances facing the firm; it is this flexibility that enables the MNC to use it as a decision variable.

The ability to choose the currency denomination of contracts would serve to facilitate this pricing strategy. By invoicing in the currency of the importing country, and with the ability to determine the timing of the payment, the MNC is in a position where exchange rate fluctuations that occur in the interim can be effectively bypassed. In other words, the bargaining problem that besets arms-length trade no longer applies to intra-firm trade, and the currency denomination of contracts becomes a choice variable that can be used to facilitate competitive pricing strategies (Mirus and Yeung, 1987). In the Australian case for instance, evidence presented to the PSA's (1989, p.51) inquiry confirms this view:

"... imports by subsidiaries of multinational companies from parent companies overseas are frequently denominated in Australian dollars ... In this way, the parent company bears the cost of exchange rate movements, at least in the short-term. The parent company can balance its global exchange risks, while allowing greater stability of prices and profit margins in Australia, where domestic producers may be the major source of competition".

As noted earlier, a vast literature exists on the various tools and techniques available to, and frequently used by, MNCs in the pursuit of global profit maximisation

the remedy is not re-estimation with correction for serial correlation, but a revised specification. This problem is rooted in the methodology employed in the specification search for an appropriate model. With the exception of Athukorala and Menon (1993), the approach to model building used in other studies has been the "bottoms-up" or "specific to general" approach. This approach, as distinct from the "general to specific" approach, prevents the investigator from distinguishing between serial correlation in the error process and the presence of a "common factor" in the lag distributions (Hendry and Mizon, 1978).

These problems are also due, in part, to the fact that little attention has been paid in these studies to diagnostic model evaluation. Most studies report only the standard summary statistics, and ignore important tests such as those that check for possible mis-specification of the regression and exogeneity of the regressors. With the exception of Athukorala (1991) and Athukorala and Menon (1993), the only diagnostic test that has been applied in previous studies is the test for structural stability of the equations. With the exception of Kim (1990), these studies have employed the conventional Chow test to test for a structural break in the pass-through relationship. The problem with the Chow test is that we are required to make the assumption that a possible break point is known *a priori*, which may not be the case. Kim (1990) employs a more general framework in the form of the varying parameter approach to test the structural stability of the pass-through equation. This framework appears much more suited to the task. It also allows for a more reliable test of the hypothesis of asymmetric pass-through during periods of depreciation and appreciation of the exchange rate.

3.1.4 Findings

In summarising the findings of previous studies, we concentrate on the following issues: (i) the degree and dynamics of the pass-through of exchange rate changes to prices, (ii) the pattern of pass-through across countries, (iii) the diversity in pass-through estimates across studies for a given country, (iv) the pattern of pass-through across products, and (v) the stability of the pass-through relationship. These issues are discussed in turn.

3.1.4.1 Pass-through: Degree and Dynamics

It is clear from Table 1 that incomplete pass-through is a common and pervasive phenomenon across a broad range of countries. Only 6 out of the 46 studies report complete or close to complete pass-through. These are Spitaeller (1980), Garnaut and

The only way to adjudicate on this debate is to employ an appropriately disaggregated industry or product-based approach, and to consider NTB-restricted and computer and business machines imports separately from total imports.

3.1.3 Methodology

Most of the previous researchers have employed OLS to estimate pass-through⁹. In almost all cases, polynomial distributed lags are used to capture the dynamic response of traded goods prices to exchange rate changes. With the exception of Feenstra (1989), Athukorala (1991), Menon (1992b) and Athukorala and Menon (1993), previous researchers have not paid any attention to the time series properties of the data. There is now a considerable body of literature that suggests that a large number of macroeconomic series and asset prices such as exchange rates are non-stationary (Nelsson and Plosser, 1982). If OLS is used to estimate a regression using non-stationary data, then the problem of "spurious regressions" becomes a major concern. Given that the data used to estimate pass-through is usually trended, it is likely that previous estimates of pass-through may have been biased as a result of the non-stationarity of the data¹⁰. This concern is heightened by the fact that a significant number of studies report high R^2 and low Durbin-Watson (DW) statistics, which may reflect non-stationary residuals. In such cases, and particularly when $R^2 > DW$, the likelihood of the relationship being "spurious" is extremely high (Hendry, 1986).

The common response in these studies to the presence of serial correlation has been to apply the Cochrane-Orcutt transformation or one of its derivatives. The application of standard autocorrelation correction procedures in the presence of non-stationary variables can lead to highly misleading results (Granger and Newbold, 1977). As Hendry (1980) puts it, "autocorrelation corrections still left rainfall as a 'significant cause' of inflation"¹¹. Even if the variables are stationary, repeated application of the Cochrane-Orcutt procedure to "mop-up" the autocorrelation will enforce a mean lag of zero, irrespective of the true underlying dynamic responses (Hendry 1986, p. 207).

Hendry (1980) points out that the presence of serial correlation may be indicative of the failure of the model to represent adequately the data-generating process. The implication is that the model may be subject to specification error. If this is true, then

(9) The exceptions are Schembri (1989), Ohno (1989), Kim (1990), Marquez (1991) and Kasa (1992).

(10) For an up-to-date survey of the literature on unit roots and cointegration, see Dolado *et al* (1990). Cuthbertson *et al* (1992, Chapter 4).

objectives. The problem with this literature is that it has thus far failed to recognise that the volatile climate of floating exchange rates poses a much more serious and pressing problem for MNCs. This involves the response mechanism of MNCs to prevent massive and sustained exchange rate movements from either forcing them into pricing themselves out of the market, or squeezing profit margins to the point where significant losses are incurred to remain competitive in export markets. Faced with these options, it should not seem surprising that MNCs have employed the available means (as discussed above) to effectively side-step the exchange rate, and the problems it poses. It is as a consequence of the employment of these means that the pass-through relationship is radically altered.

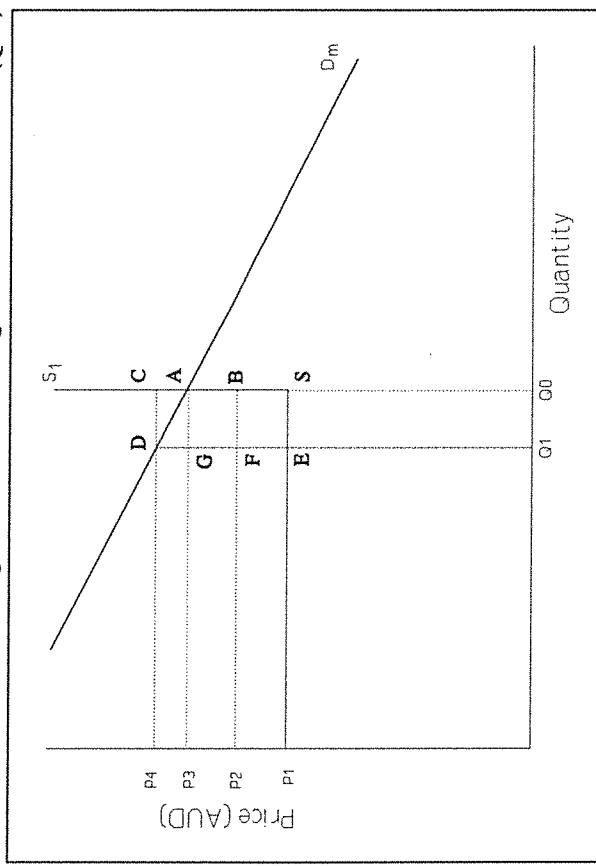
2.4 Non-Tariff Barriers (NTBs)

The important role played by the increasing presence of NTBs to international trade in affecting the pass-through relationship has been recently emphasised by Bhagwati (1988) and Branson (1989). In the US case, where much of the interest in pass-through has concentrated, Bhagwati (1988, p.1) claims that "a major and indeed obvious explanation (for the change in the pass-through relationship) has simply been missed. It lies, of course, in the fact that the early 1980s (when the US dollar was overvalued) saw a significant rise in non-tariff barriers ...". This view is supported by Branson (1989), who clearly spells out the process by which NTBs influence the pass-through outcome: "The increase in the coverage of NTBs as the dollar depreciated would hold up import prices. Then as the dollar depreciated from 1985, the premium on NTB-restricted imports would fall instead of import prices rising. Pass-through would imply reduction of the premium on imports rather than rising prices...". In other words, depreciations in the presence of import restraints will generally cut into the import premium first, thus absorbing much of its impact, before it is reflected in prices. It is only when the depreciation is large enough to push prices to the point where quantity restraints are no longer binding that we will observe some pass-through⁷.

(7) It is important to note the differential effect that quantitative restraints and tariffs have on pass-through. A tariff imposed on a product raises the supply price for every quantity by the amount of the tariff. This may not by itself have any effect on the degree of pass-through. For instance, a tariff imposed on a product sold under competitive conditions would be fully passed-through to selling prices. Tariffs are likely to affect the pass-through relationship only when imposed on a product sold in a market characterised by imperfect competition. Under these conditions, foreign sellers may use their market power to translate changes to tariff levels into monopoly profits, rather than passing them on to prices. Feenstra (1989) tests the hypothesis of symmetric pass-through of (what are perceived as "permanent") exchange rate changes and tariffs, and finds that the hypothesis was easily accepted for his sample (see Table I). As shown in Section 2.2.1, pass-through would be complete in perfectly competitive markets, and given the symmetry hypothesis, so would tariff changes. Quantitative restraints, on the other hand,

The effects of QRs in limiting the pass-through of exchange rate changes to import prices is depicted in Figure 1. To highlight the role of QRs in limiting pass-through, Figure 1 considers the case of a "small" country which is a price-taker with respect to its imports. D_m is the demand curve for imports, and the supply curve for imports is composed of the horizontal segment P_1S and the vertical segment SS_1 . The supply curve is perfectly elastic at the world price of P_1 (reflecting the "small" country assumption), and becomes perfectly inelastic when it encounters the QR at quantity Q_0 . The initial equilibrium is at point A, at market price P_3 and quantity Q_0 . As a result of the quantitative restraint, the seller is able to extract P_1SAP_3 in quota rents.

Figure 1
Exchange Rate Pass-Through in the Presence of Quantitative Restrictions (QRs)



will affect the pass-through relationship even under conditions of perfect competition. Unlike tariffs, the effect that quantitative restrictions will have on the pass-through relationship does not depend on particular market structures. The price and output effects of the imposition or the removal of a tariff or quota in a perfectly competitive market will be equivalent, however.

Like the measurement of the import price, the measurement of the exchange rate has attracted some attention in the literature (see Woo, 1984; Klein and Murphy, 1988; Citrin, 1989; Feinberg, 1991; Athukorala and Menon, 1992). Only Athukorala and Menon (1993) employ a currency-contract-weighted exchange rate index, which is obtained by dividing export prices measured in Yen by export prices measured in the currency in which the contract is denominated. This index is a true representation of the extent of the exchange rate fluctuation faced by the exporting country (see Magee and Rao, 1980). The other studies employ a proxy in the form of a trade-weighted exchange rate index. These studies highlight the importance of factors such as the number of currencies included and the weighting scheme employed to construct this index. These factors are likely to bear significantly on the degree to which the index under or overstates the currency fluctuation. As a result, the estimate of pass-through, which is the *degre* to which import prices respond to these *changes*, is likely to be affected.

Less than half of the studies employ a disaggregate approach to analysing pass-through. Only a handful of these studies use a data set disaggregated at the product level. This raises the concern of possible aggregation bias in the pass-through estimates, especially given the fact that studies such as Feenstra (1989), Marston (1990) and Menon (1992a) find significant differences in rates of pass-through across products. Furthermore, disaggregating the data would also enable more accurate estimation of the time-lags involved in the transmission of exchange rate changes to prices (Hooper and Mann, 1989).

The issues relating to an appropriate disaggregation of the data have become particularly important in the pass-through literature since studies such as Citrin (1989) and Lawrence (1990) have emerged claiming that much of the "pass-through puzzle" lies in the data and not in actual behaviour. As noted above, these studies suggest that previous findings of incomplete pass-through for aggregate US imports have resulted from the inclusion of computer and other business machines imports, whose prices have fallen quite drastically in the 1980s.

Another view put forward initially by Bhagwati (1988) and pursued empirically by Mastropasqua and Vona (1989) suggests that the explanation lies instead with the recent and rapid growth of NTBs on certain imports to the US, which has distorted the pricing relationship and the way prices respond to external shocks such as exchange rate changes (see Section 2.4). Once again, the argument is that the aggregate pass-through estimate has been biased by the distorting influence of NTBs on the pricing relationship of a significant number of component categories of imports.

Table 2
Number of Estimates of Pass-Through by Country

| Country | Number of Estimates |
|------------------|---------------------|
| US | 27 |
| Japan | 7 |
| Australia | 7 |
| Germany | 6 |
| Canada | 4 |
| UK | 3 |
| Korea | 3 |
| France | 2 |
| Netherlands | 2 |
| Belgium | 2 |
| Italy | 2 |
| Taiwan | 1 |
| Botswana | 1 |
| Papua New Guinea | 1 |
| Austria | 1 |
| Denmark | 1 |
| Finland | 1 |
| Norway | 1 |
| Spain | 1 |
| Sweden | 1 |
| Switzerland | 1 |
| Indonesia | 1 |
| Malaysia | 1 |
| Singapore | 1 |
| Thailand | 1 |
| Total | 78 |

Source: Table 1

Assume that there is initially a "small" depreciation of the currency. While the vertical portion of the supply curve will remain unchanged, the horizontal portion will now shift to P_2B . The market price will remain at P_3 , however, and the depreciation is absorbed into the quota rents extracted by the seller (now reduced to P_2BAP_3). The pass-through of the depreciation is zero. Now consider the case where the depreciation is large enough to push the price up to the point where the quota is no longer binding. The depreciation pushes the horizontal portion of the supply curve up to P_4C , which is higher than the original market price of P_3 . The equilibrium quantity now falls below the quota limit to Q_1 . From Figure 1, it is easily seen that pass-through is going to be less than complete. The pass-through (PT) of the depreciation in this instance is going to be:

$$PT = \{(P_4 - P_3)/P_3\} / \{(P_4 - P_1)/P_1\} < 1$$

3. Exchange Rate Pass-through: Evidence

Having pieced together the theory underlying pass-through, we now proceed to examine the empirical evidence on the issue. Our survey of the empirical literature covers 46 studies on the pass-through issue. Of these studies, 19 examine the pass-through to import prices, 10 examine the pass-through to export prices, 13 examine both, and 3 examine the pass-through to domestic producer prices. 10 out of 32 studies on import price pass-through, and 8 out of the 23 studies on export price pass-through, examine trade on a bilateral basis. 6 out of the 23 studies on export price pass-through investigate the pricing to market phenomenon. That is, these studies seek to determine whether exporters resort to price discrimination across export markets, or between the domestic and export market(s) in limiting pass-through.

For ease of reference, these studies are summarised in tabular form, with separate columns that identify the study, describe the data base and methodology, and summarise the key findings. The first group of studies are the multi-country studies. The rest of the studies are grouped by country, and appear in alphabetical order. For each country, the studies are listed in chronological order, based on year of publication.

| Multi-Country | |
|-----------------|---|
| Study | Data and Method |
| Kreinin (1977) | Multi-country analysis of import and export price pass-through covering the period 1970 to 1972. Traded goods prices are proxied by the consumer price index. Pass-through is measured as the difference between the hypothetical price change (using the control country approach) and the actual price change following an exchange rate adjustment. |
| Spiethel (1980) | Multi-country analysis of import and export pass-through covering the period January 1973 to April 1978. Traded goods prices are unit values. Examines the response of traded goods prices to a 10 percent depreciation in the short (6 months) and long (2 years) run. Ordinary Least Squares (OLS) used to estimate model. |
| | Multi-country (23 countries) analysis of pass-through for aggregate exports covering the period 1975q1 to 1987q4. Export prices are mainly unit values. Wholesale prices used to construct cost of production index. OLS regressions fitted to first-differences of the variables. |
| | and Khosla and Teranishi (1989) |
| Findings | Pass-through generally incomplete, and tends to vary inversely with the size of the country. The individual country estimates for import pass-through of a 10 percent depreciation are as follows: i) US - 50 percent, ii) Germany - 60 percent, iii) Japan - 80 percent, iv) Canada - 90 percent, v) Belgium - 90 percent, vi) Italy - 100 percent. |
| | Short-run pass-through is incomplete for France (83 percent), Germany (73 percent), Netherlands (66 percent), UK (93 percent) and US (71 percent). Long-run pass-through is complete for all countries except Germany, which remains at 73 percent. |
| | Multi-country (23 countries) analysis of pass-through for aggregate exports covering the period 1975q1 to 1987q4. Export prices are mainly unit values. Wholesale prices used to construct cost of production index. OLS regressions fitted to first-differences of the variables. |
| | through ranges from a high of 96 percent for Sweden to a low of zero for Norway. Surprisingly, the larger developed economies such as the US and Japan record relatively high rates of pass-through (87 and 92 percent, respectively), where as the smaller and less developed economies such as the Philippines and Indonesia record relatively low rates of pass-through (27 and 17 percent, respectively). |

Table 1 The Empirical Literature on Exchange Rate Pass-through: A Summary of Data, Methodology and Findings

3.1 Salient Features of Previous Studies

There are a number of issues that emerge from the survey of the pass-through literature that require closer attention. These issues relate to the: (i) country-coverage, (ii) data, (iii) methodology, and (iv) findings. We discuss these in turn, starting with the nature of the country-coverage in the pass-through literature.

3.1.1 Country-Coverage

Much of the work on pass-through has concentrated on the experience of the larger economies, particularly that of the US. This is borne out in Table 2, which lists the number of estimates of pass-through available for each country. More than 50 percent of the available estimates of pass-through are for the US, Japan and Germany. The experience of the smaller and more trade-dependent economies has received less attention. Although Australia ranks an equal second with Japan on this scale with 7 estimates, 3 of these are based on surveys.

Furthermore, the estimates for most of the so-called small open economies are obtained from studies that examine pass-through in a multi-country context. In fact, the only estimate available for 12 out of the 19 small country cases are provided by Khosla and Teranishi (1989). It would clearly be unwise to accept the estimates from a single study to represent the conventional wisdom on pass-through in each of these countries, or for the smaller economies in general. The other studies that have examined pass-through for the smaller economies have also produced mixed results, leaving the issue very much unresolved. This is particularly true in the case of Australia, where the results from different studies have often been contradictory.

3.1.2 Data

Most previous researchers have relied on price proxies such as import unit values to represent transaction prices of imports, which are subject to a number of well-known limitations⁸ (see, for instance, Lipsey *et al.*, 1991). The bias introduced into estimates of pass-through as a result of measurement errors inherent in price proxies is highlighted by Alterman (1991) when he compares the results obtained using import prices versus import unit values. The discrepancy between the estimates is large enough to warrant concern over the reliability of pass-through estimates obtained using price proxies (Table 1).

(8) The exceptions are Lattimore (1988), Phillips (1988), Hooper and Mann (1989), Feenstra (1989), Marston (1990), Khosla (1991), Alterman (1991), Athukorala (1991), Athukorala and Menon (1993), and Menon (1992a, 1992b).

Table 1 (Cont.)

| US (Cont.) | | |
|-----------------|---|--|
| Study | Data and Method | Findings |
| Alterman (1991) | Aggregate and disaggregate (15 2 and 3-digit SITC) data for US imports and exports for the following two subperiods: i) September 1980 to March 1985 (USD appreciation), and ii) March 1985 to December 1988 (USD depreciation). Compares pass-through estimates obtained using Bureau of Census unit value indices and BLS import price indices. Trade-weighted average of the CPIs of the 40 major exporters used to proxy for foreign costs of production index. OLS used to estimate model. | Pass-through generally incomplete for exports and imports, and varies significantly by product category. Aggregate pass-through of 48.7 percent. Pass-through on imports using unit values significantly lower than those obtained using the BLS import price index. In the case of capital goods, for instance, pass-through is 50 percent using the BLS index and 33 percent when unit values are used. Significant differences in rates of pass-through during depreciations and appreciations. |
| Kasa (1992) | Disaggregate (8 7-digit SITC) data for US and Canadian imports of German goods for the period January 1978 to December 1987. Price data are import unit values. SUR method used to estimate model. | Pass-through incomplete and varied significantly from product to product. Price of German imports in US rose relative to Canada following USD/Mark appreciation, indicating a lower rate of pass-through in the US compared with Canada. Degree of pricing to market affected by the transitory component in exchange rate fluctuations. This pattern confirmed by comparing the restricted and unrestricted impulse response functions in the two markets. |

Table 1 (Cont.)

| Australia | | |
|---|--|---|
| Study | Data and Method | Findings |
| Bureau of Industry Economics (BIE) (1986) | Data based on a survey of 83 importers and 109 import using and import competing manufacturers in November and December 1985. Questionnaires were supplemented by personal interviews with 37 of these firms in May 1986. | Pass-through ranged between 52 and 107 percent. Local importers raised their prices, on average, by 22 percent during 1985, thus absorbing much of the initial impact of the depreciation. Survey indicated that majority of firms expected to restore unit profit margins by June 1986. |
| BIE (1987) | Combination of survey, unit value and Australian Bureau of Statistics (ABS) data for the metal fasteners and steel industries. Survey data was collected in 1985, and supplemented by personal interviews with 10 firms. The ABS data for metal fasteners and steel imports are for the period 1983q2 to 1986q3. | Pass-through for the metal fasteners industry was around 75 percent, with about 50 percent passed-through in the first quarter, and 25 percent in the next quarter. Pass-through for individual import sources of metal fasteners were: (i) Taiwan - 73, (ii) Japan - 83, (iii) US - 62, and (iv) UK, New Zealand - greater than 100. Pass-through of about 60 percent for steel imports from Japan, and 115 percent from France. |
| BIE (1988) | Combination of survey and ABS data for Australian imports of metal working machine tools. Survey data based on the seven major firms in the industry collected between December 1986 and May 1987, with personal interviews supplementing questionnaires. ABS data covers the period 1977q4 to 1986q4. | Pass-through for the industry based on ABS data was 96 percent. Pass-through ranged between 62 to 103 percent for individual products using the firm-level survey data. |

| Australia (Cont.) | |
|-------------------|---|
| Study | <p>Lattimore (1988) Disaggregate data covering 12 2-digit Australian Standard Industry Classification (ASIC) industries for Australian imports for the period 1981q3 to 1987q4. Import prices are true prices.</p> |
| Data and Method | <p>Disaggregate data for 34 1 and 2-digit Australian Import Commodity Classification (AICC) industries for the period 1981q3 to 1987q4. Import prices are true prices. Apart from transport and other equipment and machinery, the foreign price index constructed as weighted average of aggregate export price indices of import-supplying countries. OLS used to estimate model with Cochrane-Orcutt transformation to correct for serial correlation.</p> |
| Findings | <p>Pass-through to be lower for the subperiod 1984q4 to 1987q4, compared to the total sample. Lags in pass-through relatively simple, usually limited to one quarter. Attempts to explain inter-industry differences in pass-through (for the subperiod) using industrial organisation variable was relatively unsuccessful.</p> |
| Study | <p>Menon (1992a) Disaggregate (5 2-digit Australian Export Commodity Classification (AEECC)) data for Australian exports for the period 1980q1 to 1990q4. Export prices are true prices. Foreign-weighted average of producer prices of destination countries for particular industry. OLS used to estimate model.</p> |
| Data and Method | <p>Disaggregate (5 2-digit Australian Export Commodity Classification (AEECC)) data for Australian exports for the period 1980q1 to 1990q4. Export prices are true prices. Foreign-weighted average of producer prices of destination countries for particular industry. OLS used to estimate model.</p> |
| Findings | <p>Pass-through close to complete for textiles and basic metal product, 40 percent for chemicals and 50 percent for transport equipment. Lags in pass-through ranged between 2 and 4 quarters. Suggests that pricing practices of multinational corporations (MNCs) on intra-firm trade in majority foreign owned industries may account for pass-through findings.</p> |

Table 1 (Cont.)

| US (Cont.) | |
|-----------------|---|
| Study | <p>Yang (1991) Aggregate data for US imports for the period 1975q2 to 1988q4. Fixed-weight import price index for total manufactured imports and wholesale prices to proxy for foreign costs.</p> |
| Data and Method | <p>Aggregate data for US imports and exports for the period 1978q1 to 1986q4. Estimates a modified version of the Helkie-Hooper (1988) model which replaces the variable-weight implicit deflator for imports with a fixed weight import price index, and one that excludes computers. Foreign cost of production index is a weighted average of consumer prices of the other G-10 and 8 major developing countries. OLS used to estimate model.</p> |
| Findings | <p>Import and export price pass-through are insensitive to both the use of a fixed weighted index and the exclusion of computer prices. Pass-through is about 85 percent in all cases for exports and imports.</p> |
| Study | <p>Meade (1991) Aggregate data for US imports and exports for the period 1978q1 to 1986q4. Estimates a modified version of the Helkie-Hooper (1988) model which replaces the variable-weight implicit deflator for imports with a fixed weight import price index, and one that excludes computers. Foreign cost of production index is a weighted average of consumer prices of the other G-10 and 8 major developing countries. OLS used to estimate model.</p> |
| Data and Method | <p>Re-estimates the domestic price pass-through results of Feinberg (1989) using three alternative measures of the real exchange rate: i) Dallas Fed Index (RX101) - broad index of 101 currencies, ii) Federal Reserve Board Index (FEDRXCH) - narrower index of 10 major currencies, and iii) Industry-specific Indexes (RXIND) - 31 currencies weighted using average import shares for 1978, 1981 and 1984. OLS used to estimate model.</p> |
| Findings | <p>Pass-through tends to vary depending on the measure of the exchange rate used. Pass-through of 24 percent using RX101, 14 percent using FEDRXCH, and 13 percent using RXIND. The performance of the market structure variables in explaining inter-industry differences in pass-through is the same as in Feinberg (1989), except that the seller concentration variable is estimated to be significantly different from zero.</p> |

Table 1 (Cont.)

Table 1 (Cont.)

| US (Cont.) | | |
|-----------------|--|--|
| Study | Data and Method | Findings |
| Lawrence (1990) | Aggregate semi-annual data for US non-oil, non-computer imports from Japan, and total non-agriculture, non-computer exports to Japan for the period 1976 to 1990. OLS used to estimate model, with Cochrane-Orcutt transformation to correct for serial correlation. Almon lags used to capture dynamics. | Suggests that the change in the pass-through relationship in the second half of the 1980s reported in previous studies would not exist if computer prices were excluded from the import price index. States that "the mysteries of recent US trade performance lie in the data, not in actual behaviour" (p. 380). Finds that export and import prices have responded symmetrically to the rise and fall of the USD. |
| Kim (1991) | Aggregate data for US multilateral imports for the period 1974q1 to 1989q2, and bilateral US trade with Japan and Germany for the period 1974q1 to 1988q4. Exchange rate and price indices are weighted averages (based on 1978-82 average trade shares) of the 6 major trading partners for US multilateral imports. All variables detrended by regressing them on a constant and time trend. Model specified as a Vector Autoregression (VAR). | Significant structural break in the equation for bilateral trade with Germany in 1982q4. Interprets this as evidence of the hysteresis effect suggested in Baldwin (1988). Only the pass-through relationship for multilateral trade has changed (i.e., is lower) in the 1980s, and concludes: "The results indicate that the pass-through problem explains the stubbornness of the US trade deficit for multilateral trade but not bilateral trade with Japan or Germany" (p. 181). |
| Marquez (1991) | Aggregate and disaggregate (6 2-digit SITC) data for US imports from and aggregate exports to Canada, Germany, Japan, US, UK, other OECD, OPEC and non-OPEC countries for the period 1973q1 to 1984q4. Full-Information Maximum Likelihood used to estimate model. | Pass-through ranges from 23 percent for the UK to 110 percent for the block of other OECD countries. |

Table 1 (Cont.)

| Australia (Cont.) | | |
|--------------------|---|--|
| Study | Data and Method | Findings |
| Menon (1992b) | Australian imports of passenger motor vehicles for the period 1981q3 to 1990q4. Import prices are true prices. Foreign cost of production index is a weighted average of industry-specific labour and material costs for the five major import supplying countries. Time-series properties of the data tested using Dickey-Fuller test. Having identified a cointegrating relationship between the independent variables, the Engle and Granger (1987) two-step procedure employed to estimate the model. | Pass-through of 80 percent in the long run, and 70 percent in the short run. Symmetry in the pass-through of changes in the exchange rate and foreign costs. Lags in short run pass-through do not extend beyond one quarter. The effect of the quantitative restriction and the pricing practices of the MNCs that dominate this industry put forward as possible explanations for the incomplete pass-through finding. |
| Botswana | | |
| Study | Data and Method | Findings |
| Clark Leith (1990) | Aggregate data for imports of Botswana for the period July 1976 to January 1987. Data for January 1988 to December 1989 used to evaluate performance of the model outside the estimation period. Consumer Price Index (CPI) is used to proxy for domestic prices, and foreign prices are based on unit values. Employs lagged dependent variable to capture disequilibrium behaviour. | Pass-through close to complete, with lags extending to 15 months. The estimated import price equation forecasts well (for outside sample) with mean-squared error of 0.00004. |

| Canada | |
|---|--|
| Study | Findings |
| <p>Schembri (1989)</p> <p>Canadian exports of intermediate inputs to the US for the period 1973 to 1985. Name of industry suppressed for reasons of confidentiality. Estimation conducted in two stages, using iterative three-stage least squares and the seemingly unrelated regressions (SURs) technique.</p> | <p>Price discrimination between the domestic (Canadian) market and the US market, with the markup on exports to the US much greater than domestic sales. Canadian exporters passed-through only a very small percentage of exchange rate depreciations, preferring instead to inflate profit margins.</p> |
| Germany | |
| Study | Findings |
| <p>Feinberg (1986)</p> <p>Annual disaggregate (41 3 and 4-digit International Standard Industry Classification (SIC)) data to study pass-through of exchange rates to German domestic producer prices for the period 1977 to 1983. Analysis in two stages: (i) estimate pass-through using industry intercept and slope dummies with 287 pooled cross-section/time series observations, and (ii) explain inter-industry differences in pass-through using market structure variables. OLS used to estimate model.</p> | <p>Pass-through of about 24 percent in real terms, i.e., 8.4 percent depreciation of the German Mark from 1977 to 1983 increased domestic producer prices by 2 percent relative to the GNP deflator. Increased market concentration reduced pass-through, while increased import penetration led to some increase in pass-through.</p> |

Table 1 (Cont.)

| US (Cont.) | |
|--|---|
| Study | Findings |
| <p>Feenstra (1989)</p> <p>Disaggregate data of US imports of motor cars, compact trucks and heavy motorcycles from Japan for the period 1974q1 to 1987q1. Price proxies in the form of wholesale unit values (inclusive of duty), or Divisia indices of several disaggregate wholesale unit values. Dickey-Fuller tests suggest variables are non-stationary, thus OLS regression fitted to differences in the variable.</p> | <p>Pass-through ranges between 63 to 89 percent, with an average lag of 4 quarters. Results for particular products based on the unrestricted regression are as follows: (i) Cars - 71.30, (ii) Trucks - 62.70, (iii) Cycles (consumption) - 89.30, (iv) Cycles (shipments) - 105.30, and (v) Cycles (pooled) - 88.60. Hypothesis of symmetric pass-through of tariff and exchange rate changes easily accepted for all products. Pricing equation homogeneous of degree one.</p> |
| <p>Froot and Klemperer (1989)</p> <p>Aggregate 2 yearly averaged data for US imports covering the period 1976 to 1986. Expected Economist and AMEX. OLS used to estimate depreciation measure from surveys by The model with standard errors corrected by White's heteroscedasticity-consistent covariance matrix.</p> | <p>Results suggest that appreciation regarded as temporary would lead to a lower rate of pass-through into import prices than purely temporary appreciation could increase USD import prices. The interpretation is that both present and expected future market share affects the degree of pass-through.</p> |
| <p>Kim (1990)</p> <p>Aggregate data for US imports for the period 1968q1 to 1986q4. Wholesale prices used to proxy for export prices, and unit values for import prices. A varying parameter approach in the form of the Kalman filter used to estimate time-variations in the pass-through relationship.</p> | <p>Reduced sensitivity of import prices to exchange rate changes in the 1980s, with significant "pricing to market" behaviour. The smoothed-parameter estimates confirm the original pass-through findings, with variations in the mark-up factor employed to insulate prices from exchange rate changes.</p> |

Table 1 (Cont.)

Table 1 (Cont.)

| US (Cont.) | | |
|-----------------|--|---|
| Study | Data and Method | Findings |
| Feinberg (1989) | Annual disaggregate (84 4-digit ISIC) data to study pass-through of exchange rates to US domestic producer prices for the period 1974 to 1987. Analysis in two stages: i) estimate pass-through using industry intercept and slope dummies with 1280 pooled cross-section/time series observations, and ii) explain inter-industry differences in pass-through using market structure variables. | Average pass-through of 16 percent in real terms. Pass-through close to complete for industries heavily reliant on imported inputs and producing goods highly substitutable for imports. Pass-through much lower for highly capital intensive and concentrated industries and those protected by extensive barriers to entry (both domestic and foreign). Estimated coefficient of seller concentration not significantly different from zero. |
| Citrin (1989) | Aggregate data for US non-oil imports excluding business machines and US exports excluding business machines for the period 1974q1 to 1984q4. Equations estimated using OLS with Cochrane-Orcutt correction for serial correlation. | Exchange rate changes fully passed-through to import prices in the long-run, although significant deviations occur in the short-run. Transmission process takes three quarters, with one third of the exchange rate change being passed-through per quarter on average. Highlights the importance of excluding business machines from the aggregate index, given the massive fall in price over the period, and choosing the correct exchange rate index. |
| Fischer (1989b) | A cross-section analysis based on data for 9 SITC 2-digit industries covering Japanese and German exports to the US for the period 1984 to 1986. | Japanese and German exporters cut mark-ups significantly in 1986 following the USD depreciation. Only Japanese export mark-ups were significantly correlated with industry concentration in 1984 (during USD appreciation). Very weak rank correlation between export price mark-downs and industry concentration in either country during 1986. |

Table 1 (Cont.)

| Japan | | |
|----------------|---|---|
| Study | Data and Method | Findings |
| Ohno (1989) | Disaggregate data covering 7 2-digit ISIC and 12 4-digit ISIC industries for US and Japanese domestic and export sales for a sample that begins within the range of 1977q4 and 1983q3 to 1987q3. Iterative three-stage least squares method, with a constant and once-lagged dependent and independent variables as instruments. | Pass-through on exports of around 80 percent. Japanese firms price-discriminate between domestic and export markets, particularly following exchange rate changes. In contrast, American exporters do not tend to price discriminate between domestic and overseas markets, with their pricing decision based on domestic cost factors. Some evidence of a structural break in the pass-through equation for Japanese exports of machinery and equipment in the early 1980s. |
| Marston (1990) | Disaggregate data covering 17 3 and 4-digit Standard International Trade Classification (SITC) products in the transport equipment and electrical machinery industries for Japanese multilateral exports and domestic sales for the period 1980 to 1988. Price data are actual export prices. Method used aims to distinguish between planned changes in profit margins and changes induced inadvertently by exchange rate "surprises". OLS used to estimate model. | "Pricing to market" behaviour widely practised in all but 2 industries. For 5 out of the 17 products, pass-through is higher during periods of appreciation compared with depreciation. |
| Khosla (1991) | Disaggregate (14 2-digit ISIC) data for Japanese exports for the period 1975q1 to 1987q4. Chow test used to test for structural break. Cost of production index is an input-output weighted index of materials and productivity-adjusted labor cost. OLS used to estimate model. | Pass-through generally incomplete, with an average of 43 percent. Significant differences in pass-through across industries. Pass-through in materials industries lower on average than final goods industries. Structural break identified in only two equations (textiles and general machinery), thus lending little support to the hysteresis hypothesis. Pass-through varied depending on whether the currency had depreciated or appreciated in only four out of the fourteen industries. |

| Japan (Cont.) | |
|---------------|--|
| Study | Disaggregate data (7 2-digit ISIC) for Japanese exports for the period 1980q1 to 1990q4. Currency-contract-weighted exchange rates obtained by dividing export prices in Yen by export prices in contract-currency terms. Time-series properties of the data tested using Dickey-Fuller and Johansen (1988) tests. Hendry's general-to-specific methodology employed in specification search. A 2-equation model comprising an export price and cost equation estimated in error-correction form. |
| Findings | Pass-through incomplete in all cases. By separating the pricing to market effect from the cost-changing effect of exchange rate changes, the findings dispute the widely held view that Japanese exporters have relied more heavily on pricing to market strategies during the period following the Plaza Agreement in 1985. In the case of total exports, the measure of pass-through is 22 percent when only pricing to market behaviour is considered, but 34 percent when cost implications of exchange rate changes are also taken into account. No evidence of a structural break in any of the equations. |
| Korea | |
| Study | Data for Korean exports of total non-food manufactures (TMF), textiles, clothing and footwear (TCF), metal products (MPR) and machinery and transport equipment (MTE) for the period 1980q1 to 1989q1. Price data are "true" prices. Time-series properties of the data tested using Dickey-Fuller test. Since all variables $I(1)$, OLS regression fitted to first differences. Battery of diagnostic tests employed. |
| Findings | Pass-through of 71 percent for TMF, 82 percent for TCF, 74 percent for MPR, and 73 percent for MTE. Lags in pass-through range between 4 to 5 quarters. Chow test and intercept dummy variable reject the hypothesis of asymmetric pass-through during periods of depreciation and appreciation. |

Table 1 (Cont.)

| US (Cont.) | |
|------------------------|---|
| Study | Data and Method |
| Moffet (1989) | Aggregate data for US imports for the period 1967q1 to 1987q4. Morgan Guaranty's 15-country index used as exchange rate variable, and index of foreign producer prices constructed using average 1983-84 weights for the 8 largest non-oil trading partners. Model in log-linear functional form estimated using OLS with polynomial distributed lags (second-order without tail constraint). |
| Hooper and Mann (1989) | Aggregate data for US manufactured imports and US manufactured imports from Japan for the period 1973q1 to 1988q2. Import price is a fixed-weighted average of import prices of capital, automotive and consumer goods and industrial supplies excluding petroleum. Unpublished data from the IMF used to construct foreign cost indices. Model estimated with OLS with Cochrane-Orcutt transformation to correct for serial correlation. Dynamics captured using unconstrained and polynomial (second degree with tail constraint) distributed lags. |
| Findings | Pass-through of around 50 percent, with lags extending to eight quarters. Dummy variable sensitivities on pass-through under fixed versus floating exchange rate regimes were found insignificant, implying no structural break in the pass-through relationship over this period. Pass-through not affected by the direction of the exchange rate change. Concludes that as a result of incomplete pass-through behaviour, trade balance response to exchange rate depreciation tended to resemble a sine wave, rather than a J -curve. |
| Findings | Pass-through for total manufactured imports range between 60 and 74 percent, with lags extending from 5 to 7 quarters. Pass-through for manufactured imports from Japan were quite similar, ranging between 67 to 72 percent with lags extending from 5 to 7 quarters. Pass-through of changes in the exchange rate and foreign costs are relatively equal. |

Table 1 (Cont.)

Table 1 (Cont.)

| US (Cont.) | | |
|-------------------------------|---|--|
| Study | Data and Method | Findings |
| Baldwin (1988) | Aggregate data for US imports for the period 1967q1 to 1987q2. Import prices are unit values. OLS used to estimate model. | Evidence of a structural break in the pass-through relationship during the phase of currency appreciation in the early 1980s. Suggests that large real exchange rate shocks can have permanent effects by altering market structure and inducing hysteresis. Sustained appreciation resulted in an increased number of foreign sellers in the US market, increasing competition and pushing prices down. This finding is at odds with other US studies that have found that profit margins were increased during the appreciation. |
| Klein and Murphy (1988) | Aggregate data for US imports from Germany and Japan, and US exports to Germany for the period January 1977 to February 1988. Unit values used as proxies for all prices. | Average multilateral pass-through of 85 percent. Pass-through appears to be time-dependent. All bilateral pass-through elasticities lower for the post-1985 US dollar (USD) depreciation compared to the 1977-80 USD depreciation. Suggests that relevant third-country exchange rates should not be ignored in estimating pass-through. |
| Mastro-pasquo and Vona (1988) | Aggregate data for exports to the US from developed and developing countries for the period February 1976 to March 1987. Traded goods prices are unit values. OLS used to estimate model. | Pass-through of 24 percent on exports from developing countries, with lags extending to 3 quarters. Found a significant break in the pass-through relationship for developed country exports in May 1982, with pass-through changing from 88 percent to 50 percent. Argue that this break may be attributable to the rise in the imposition of non-tariff barriers (NTBs) on developed country exports to the US during this period, in line with the "Bhagwati (1988) hypothesis". |

Table 1 (Cont.)

| Papua New Guinea | | |
|---------------------------|--|--|
| Study | Data and Method | Findings |
| Garnaut and Baxter (1984) | Disaggregate data for imports of various foods, light manufactures and consumer durables of Papua New Guinea and its various regions during the 1970s. Examines pass-through of exchange rate changes to consumer prices. Data analysis supplemented with interviews. | Pass-through of exchange rate changes to consumer prices relatively complete, although not instantaneous. Pass-through is quite rapid for traded goods. Lags appear to be the longest for durables such as household and clothing products. |
| Taiwan | | |
| Study | Data and Method | Findings |
| Moreno (1989) | Aggregate data for Korean and Taiwanese imports and exports for the period 1974q1 to 1987q4. Trade prices are unit values, and weighted average of foreign consumer prices used to construct foreign price variable. Model estimated in error-correction form using OLS. | Pass-through to export prices of 58 percent for Korea and 36 percent for Taiwan. Pass-through to import prices of 58 percent for Korea and 74 percent for Taiwan. |
| UK | | |
| Study | Data and Method | Findings |
| Cowling and Sugden (1989) | UK imports of motor cars from West Germany and UK exports of motor cars for the period 1975 to 1981. Price data comprises a sample of up to 21 models for UK exports, and up to 27 models for imports from West Germany. | Pass-through incomplete and varied across models. The substantial appreciation of the Sterling during 1979-80 led neither to a decline in the relative price of car imports into the UK, nor to a rise in relative price of car exports from the UK. |

| US | |
|--------------------------|---|
| Study | Data and Method |
| Shwartz and Perez (1974) | Analysis of survey data for US imports from Japan, West Germany, France, Belgium and Italy collected in 1972. |
| Magee (1974) | Analysis of Custom's records of US imports for the period 1971 to 1973. |
| Woo (1984) | Aggregate data for US imports (net of food and fuel) for the period 1975q2 to 1984q1. Used the bilateral import-share index instead of the Fed's multilateral index to construct the exchange rate variable on the assumption that competition from third countries unlikely to be as important in the import market compared with the export market. OLS with Almon lags and the Instrumental Variable method used to estimate model. Cochrane-Orcutt transformation used to correct for serial correlation. |
| | Pass-through within the range of 40 to 70 percent. Quotas on US imports of motor vehicles tended to distort pricing relationship. Also suggests that significant absorption of exchange rate changes may occur at the retail level, due to observed differences in the import deflator and domestic inflation indicators such as the consumption deflator. |
| | Pass-through estimates as a result of measurement errors. |
| | Currency denomination of contracts affects pass-through. The use of US customs records of US imports introduces substantial bias in pass-through estimates as a result of measurement errors. |
| | France, 65 percent from Belgium, and 71 percent from Italy. From Japan, 61 percent from West Germany, 63 percent from percent. In particular, pass-through of 68 percent for imports from Japan, West Germany, France, Belgium and Italy. |
| | Pass-through generally incomplete, ranging between 70 to 80 percent. In particular, pass-through of 68 percent for imports from Japan, West Germany, France, Belgium and Italy. |
| Findings | |

Table 1 (Cont.)

| US (Cont.) | |
|-----------------------------|--|
| Study | Data and Method |
| Mann (1986) | US imports and exports for the period 1977q1 to 1985q2, with 7 import industries and 9 export industries. OLS used to estimate model, and Almon polynomial lags introduced to capture dynamic response. Cochrane-Orcutt transformation to correct for serial correlation. |
| | Important piece of empirical work that initiated much of the recent interest in the pass-through relationship. Exporters to the US squeezed profit margins considerably in response to the dollar depreciation in 1985, resulting in a change in the historical pass-through relationship (although not significant enough to be picked up as a structural break using the Chow test). Identified asymmetries in the response of import prices to exchange rate depreciations and appreciations. |
| Kreinin <i>et al</i> (1987) | Annual disaggregate (63 4-digit SIC) data for US imports from the UK, Germany and Japan for the period 1973 to 1982. A cross-section study of the effects of exchange rate changes on prices and quantities of traded goods. Tests whether the extent of pass-through varies across products depending on characteristics of industry in which product is traded. OLS used to estimate model. |
| | Pass-through is positively related to capital intensity and negatively related to labor intensity. Industry characteristics appear to be correlated with differences in pass-through across industries, but with limited explanatory power. Pass-through varied across countries and depending on whether the exchange rate had depreciated or appreciated. |
| Helke and Hooper (1988) | Aggregate data of US non-oil imports and exports for the period 1969q1 to 1984q4. Traded goods prices are true prices. Simulation exercises to examine the response of trade prices and volumes to a hypothetical 10 percent depreciation. OLS with Cochrane-Orcutt transformation to correct for serial correlation. |
| | Pass-through on imports of 91 percent, with lags extending up to 8 quarters. Pass-through on exports ranged between 80 to 100 percent, with lags extending up to 4 quarters. |
| Findings | |

Table 1 (Cont.)