# *Relationships Between Exchange Rate Movements and Prices in Canada*

*By*

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*A Thesis Presented to Faculty of Graduate Studies, University of Manitoba in Partial Fulfillment of the Requirements for the Degree of Master of Arts in Economics*

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# RELATIONSHIPS BETWEEN EXCHANGE RATE MOVEMENTS AND PRICES IN CANADA

BY

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A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF ARTS

*To my Parents, Brothers and Sisters*

*ACKNOWLEDGEMENT*

Throughout the course of this thesis I benefited immensely from a number of people and I would like to express my appreciation to them. First and foremost, I would like to thank God for his unending support throughout the course of my studies. My sincere appreciation also goes to my thesis committee members Prof. N. Cameron (advisor), Prof. M. Boyd and Prof. L. Brown for helpful comments and suggestions. Special thanks also go to Prof. B. Troutt for her assistance throughout the course of this thesis. Finally, to A. Boame, H. Sackey and J. L. Rosmy, I will say thank you very much for moral and spiritual support.

*ABSTRACT*

This thesis examines the impact of exchange rate fluctuations on consumers by analyzing the pass-through effect of prices of manufactured imports as well as exchange rate-prices causality detection. It has measured the magnitude and the timing at which changes in exchange rates are transmitted onto prices of automobiles and electrical appliances imported into Canada from the United States over the period 1979-2000. The theoretical specification of the pass-through effects takes the form of partial equilibrium mark-up model where exchange rate pass-through is defined as a partial derivative that reflects the willingness of foreign firms to adjust their profit margins to offset changes in exchange rates. In estimating the degree and the speed of pass-through effect on prices of imported commodities, the partial adjustment models for cointegration regression were re-specified as an error correction model to separate the short-run dynamics from long run equilibrium relationships. Distributed-lag models were also applied to the pass-through equations to test for lags in pass-through while direction for exchange rate–prices causality was detected using vector autoregressive specification and minimum Akaike information criterion. The estimated results show that pass-through effect varies substantially across product categories. Irrespective of which estimation technique is employed, U.S firms passed larger amount of a change in exchange rate onto the prices of automobile imports than other categories of manufactured imports. However, the evidence is overwhelming in support of the view that the effect of exchange rate changes in Canada is now less than they had at the beginning of the floating era, and that, public expectations of the future course of monetary policy thus play a key role in the interactions between the exchange rate changes and prices.

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# *CHAPTER 1*

# *INTRODUCTION*

## *Background*

Over the past three decades, a significant change has taken place in the behavior of exchange rates. Exchange rates have moved more and more persistently than advocates of flexible rates in the late 1960s would have left anyone free to imagine. Rates of change of one percent a day, five percent a month, or twenty percent a year have not been uncommon. These fluctuations have been large relative to those of key macroeconomic variables considered to be the fundamental factors determining exchange rate movements. The Canadian experience since 1970 bears out this observation.

In the transition from fixed to flexible rates in the early 1970s, the Canadian dollar measured in terms of U.S. counterpart appreciated sharply, rising about 13 percent during the first four years ending in the second quarter of 1974. This was followed by a depreciation of about 21.6 percent that lasted throughout the rest of the decade[1]. Throughout the 1980s, the Canadian dollar traded in a wide range, weakening sharply during the first half of the decade before staging a strong recovery during the second half to close the decade at US$0.86. In 1990 and most of 1991, the Canadian dollar climbed not only against the U.S. dollar but also against other major overseas currencies. However, it depreciated by about 20 percent between 1992 and 1994. After attaining some degree of stability between 1995 and 1996, a renewed weakness in the currency began to emerge in

[1] Calculations are based on noon spot rates

1997 and became increasingly apparent in the 1998. The dollar reached an all-time low of US$0.65 in the last quarter of 1998[2].

The effects of exchange rate movements on domestic prices generally seems to have been underestimated but revealed themselves to be surprisingly large principally because of their impact on the price of import- and export-competing goods and because of subsequent real demand and wage-price effects (Wallich 1984, p.35). Large and erratic movements of the exchange rate usually create a grave concern of disorderly market behavior and increased uncertainty among foreign exchange traders and national monetary authorities. For individuals who depend on foreign currency for their economic activities, exchange rate uncertainty has increased. For national monetary authorities, price stabilization policies can be nullified in the face of unexpected fluctuations in the exchange rate (Kawai 1984, p.189).

Currency fluctuations have an impact on the general level of domestic prices. Through the responses of firms, workers and policymakers to price changes, currency fluctuations can also have an indirect effect on real economic activity. The economic response to price changes caused by movements in the exchange rate varies with economic conditions but the price effect stemming from exchange rate movements is always present[3].

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[2]Detailed discussions on the behavior of Canadian dollar can be found in Powell (1999) at http://www.bankofcanada.ca/en/dollar_book/dollar_book-e.pdf

[3] See Caramazza (1986), De Brouser et al. (1994) for an investigation of the inflationary effects stemming from exchange rate depreciation.

The extent to which exchange rate changes are reflected in the prices of imported commodities has been termed "*exchange rate pass-through*". A quite significant number of studies, including Mann (1986), Fisher (1989) and Feenstra (1989), Feinberg (1991), Dwyer and Lam (1995), Gadnon et al. (1996), Kadiyali (1997) have analyzed the exchange rate pass-through phenomenon. In general, the estimates of the portion of exchange rate changes transmitted into the import prices have hovered around 80 percent, although some of the more recent studies find figures closer to 60 percent. The time it takes for pass-through to be completed ranges from months to several years. Some of these studies have analyzed currency pass-through using disaggregated industry-level data. The general conclusion is that pass-through varies across industries.

In Canada, previous studies by Kreinin (1977), Spitaller (1980), and Kasa (1992) have estimated pass-through effect on import prices in the neighborhood of 90 percent. On the impact of exchange rate movements on the consumer prices, Duguay (1994) has suggested an impact on the order of 20 percent. This estimate roughly corresponds to the share of imports in the 1986 CPI basket of goods and services (Duguay 1994, p.57). However, a recent final-demand estimate from Statistics Canada's input-output model of the Canadian economy indicates that the share of imports in the CPI basket has risen over the years[4]. The question is: what are the current estimates of the pass-through effect of the exchange rate changes? To what extent did changes in prices of imported inputs influence consumer prices, or is there a significant causal relationship between exchange rate changes and

[4]Lafleche (1996) for instance, has attributed the rise in import share to the influence under Canada-United States Free Trade Agreement (signed in 1989 and extended to Mexico in 1994) as well as the new agreement on tariffs and trade that concluded the Uruguay Round negotiations in 1994.

prices? This study explores the dynamics of the adjustment of prices to changes in the exchange rate. This requires estimation of both pass-through effect and exchange rate–prices causality detection.

### *1.1. Objectives and Motivation for the Study*

The broad objective of this study is to assess the interactions between exchange rate changes and prices vis-à-vis their impact on consumers. To achieve this objective, the study seeks to address the following: a) to determine the current estimates of the timing and magnitude of the pass-through effect of exchange rate changes on prices of consumer goods imported into Canada, and b) to investigate the direction of causality between exchange rates and prices in Canada. The study analyzes the effect of exchange rate changes on import prices of automobile products and electrical appliances imported into Canada[5]. The automobiles and electrical appliances imports constituted about 90 percent of consumer imports of goods and have very high import content in Canada's domestic market[6].

Exchange rate fluctuations are now perceived to have less impact on import prices than they had in the beginning of the floating period (Baldwin 1988; Moffet 1989; Melick 1989). If that perception is correct, a depreciation of the currency may be less likely to fuel inflation. The study tests whether or not the pass-through relations has changed over time

[5] Electrical appliances category of manufactured imports is selected to comprise audiovisual imports and household appliances excluding capital goods and industrial suppliers. The automobile products consist of passenger cars and accessories excluding industrial vehicles.
[6] Source: 1998 International Statistics Yearbook

and ask, what would be the implications for Canadian import prices of a future decline in the Canadian dollar?

Movements in the exchange rate have an impact on the prices of imported inputs and through these price changes; there can also be either direct or indirect effect on consumer price index. Most investigations of exchange rate pass-through have focused only on the transmission of exchange rate changes onto prices of imported commodities. However, it is the consumer or retail price of imports, and not the over the docks prices, that directly enters measured inflation. Thus, understanding the adjustment of aggregate price levels as imports are distributed to local markets is central to any assessment of the inflationary consequences of currency depreciation. The study also investigates empirically the impact on consumer price to changes in prices induced by exchange rate changes and tests the validity of the hypothesis that a floating exchange rate is the main source of instability in prices and exchange rates, due to a pass-through from exchange rates to prices and a feedback from prices to exchange rates.

There are at least two underlying focal points that motivated this study of exchange rate-prices relationships. First, since the inception of floating system, a quite significant number of studies have analyzed the purchasing-power parity relationship but neither the absolute nor the relative version says anything about causation[7]. The presumption is that purchasing-power parity is a theory of exchange rate determination where exchange rate is the endogenous variable that responds to exogenous changes in relative prices. In the

[7] One theoretical criticism of PPP is that it does not explicitly specify the direction of causality.

absolute version however, the exchange rate alters to ensure that domestic and foreign price levels are brought into equality. In the relative version, exchange rate changes will offset differences in the inflation rates across countries. As a result, some authors have put exchange rate as a dependent variable while others put prices as a dependent variable without adequate justification of the form of regression equations. Using vector autoregressive specification and minimum Akaike information criterion, causality detection in this study would rationalize one form of the PPP regression equation against the other for Canadian economy.

The second concern has to do with the issue of "vicious circle" and "virtuous circle" hypotheses[8]. The effects of the exchange rate changes on prices are of great concern for countries particularly the developing nations whose currencies are pegged. The reluctance of these economies to ease their currency in the face of severe balance of payments difficulties has stemmed from their fear that unanticipated movement in the exchange rates may aggravate domestic inflation. It has been argued that for some countries, unanticipated exchange rate fluctuations have caused changes in the costs, wages and general prices that have induced further exchanges rate changes due to a feedback relationship. If causality from exchange rates to prices and feedback relationship is strongly detected in this investigation, then this hypothesis can be well supported.

[8] The Vicious circle hypothesis in its simplest form, states that in the world of floating exchange rates, an initial disturbances (either domestic or foreign) can set in motion a cumulative process of price inflation and exchange rate depreciation, through which the exchange rate effect is rapidly passed through into domestic prices and costs and back again to the exchange rates. The dual of the vicious circle thesis is the virtuous circle hypothesis, which is associated with exchange rate appreciation and price stability.

### *1.2. Outline of the Study*

This thesis consists of seven chapters of which this forms the first. Chapter two surveys the theoretical framework that has been developed in the literature to explain exchange rate-price relationships. Here, the study explores a range of models with the purpose of examining the extent to which exchange rate movements reflect changes in commodity prices. Chapter three reviews the empirical evidence for the exchange rate-pass through effect. Chapter four presents methodology adopted and derives the equations for the study. Chapter five describes the sources, choice and construction of data on prices, costs, exchange rates and other variables and reviews the movements in these series. Chapter six presents estimation results for the pass-through coefficients on exchange rates and exchange rate-prices causality relationships and test whether these empirical relationships have changed over time. Chapter seven concludes the study with a summary of the results and a brief discussion of their policy implications.

## *CHAPTER 2*

## *THEORETICAL ANALYSIS OF EXCHANGE RATE-PRICE RELATIONSHIP*

### *Overview*

Before the breakdown of the Bretton Woods system in 1971, the exchange rate literature was generally concerned with finding solutions to the problems of balance of trade. In the days of the Bretton Woods system, exchange rates were relatively stable, trade grew rapidly and macroeconomic stability was achieved[9]. For economies attempting to correct a balance of trade deficit, the fundamental question was how to get the required magnitude of the devaluation to reverse the trend. However, it was not long before strains in the system began to show. A major problem arose over the adjustment process. In particular the system could not adequately deal with the difficulty that an economy experiences when trying to re-equilibrate after a macroeconomic shock.

Proponents for the abandonment of the fixed exchange rate under the Bretton Woods system argued that in real world situations, macroeconomic shocks are bound to occur and if an economy happens to be subject to such macroeconomic disturbances, and the nominal exchange rate is not allowed to adjust to help offset them, the resulting economic pressures will shift onto other key macroeconomic variables. Since prices and wages in most real-world economies are relatively sticky, and factors of production have difficulty moving between regions or countries, the result is often greater variability in output and employment with fixed rates than would have been the case if the exchange rate had been

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[9] See McKinnon (1979) for a list of achievements of the Bretton Woods system.

allowed to move. The argument advanced against a fixed regime clearly shows that the exchange rate uncertainty and destabilizing economic forces that one had hoped to eliminate by fixing the currency may simply manifest themselves elsewhere in potentially more damaging form. Those economists who supported a floating system stated that flexible rates would permit countries to pursue independent monetary policies[10]. Thus, one of the roles of the flexible exchange rate was to cushion the economy against economic shocks (Friedman 1953, Appleyard and Field 2001).

Despite the advantages associated with floating rates, there exist some potential problems. One can argue easily that the fluctuations that have characterized the floating period have exerted undue pressure on prices, particularly prices of traded goods. The interaction between exchange rates and prices has been a most technical one and it is not surprising that a large amount of literature has been generated on the subject[11]. The literature seems to support the two-way causal effect relationship between the exchange rate and prices. We can therefore classify this causal effect relation into two distinctive causality relationships. On the one side, we have a causal relationship from prices (p) to exchange rates (e):

$$\{2.1\} \qquad e = f(p,..) \tag{2.1}$$

Thus, among other variables, exchange rate is a function of prices. Theories that explain this relationship can be classified as models of exchange rate determination. Among the

[10]For fixed-flexible exchange rate debate, see for example Appleyard and Field (2001, chp. 29).
[11] A partial list includes Branson (1972); Magee (1973); Kreinin (1977); Spitaller (1980); Krugman (1986); Dornbusch (1987); Feenstra (1989); Fisher (1989); Mann and Hooper (1989); Ohno (1990), Menon (1995), Gagnon *et al.* (1996).

theories that seek to explain the exchange rate movements are purchasing power parity theory (Cassel 1918) and asset market models: the monetary approach (Frenkel 1976; Bilson 1978) and portfolio balance approach (Branson 1977). On the other side is a causal relationship from exchange rates to prices:

$$\{2.2\} \qquad p = f(e,...)$$

That is, price is a function of exchange rate. The extent to which exchange rate changes are transformed into changes in import prices is called the currency pass-through[12]. Pass-through models have both microeconomic and macroeconomic underpinnings but data availability has forced the majority of the empirical studies to concentrate on macroeconomic issues. With the experience of the present floating period, there is no justification to the belief that causality runs only in one direction. The bi-directional causal relationship between exchange rates and prices may not be obvious *a priori* but we expect it to exist[13]. We can envisage some form of circular flow between exchange rates and prices with perhaps one direction dominating and the other providing feedback effect[14].

[12] One of the early-1970s' studies on the broader question of currency pass-through is Branson's (1972) paper, which assessed the possible response of the U.S. trade deficit to the devaluation of the dollar. In Branson's (1972 p.53) sense, pass-through means that "in devaluing countries the domestic currency price index of imports should be rising substantially, while in upvaluing countries it should be falling".

[13] Economists including Kawai (1984), Caramazza (1986) have found evidence for two-way causal effect relationship between exchange rate and prices.

[14] Basevi, G., and De Grauwe (1977) have related the "vicious circle" hypothesis to exchange rate-price causality when initial perturbation stemmed from depreciation and "virtuous circle" when the initial disturbance is as a result of appreciation

In this chapter, I present a brief synopsis of a range of models with the goal of examining changes in the exchange rate and the extent to which they reflect changes in commodity prices. Each model is summarized briefly, followed by a brief discussion of its applicability to the issue of exchange rate-price relationship. The chapter is divided into three sections. Section 2.1 analyzes pass-through theories (i.e. the impact of exchange rate changes on import prices). When domestic currency depreciates, it affects prices of imported inputs and through these price changes, there can also be a change in the consumer retail prices. Section 2.2 examines how consumer prices respond to changes in prices of imported inputs following exchange rate changes[15]. Feedback from prices to the exchange rate is analyzed in section 2.3.

### *2.1. Exchange Rate Changes And Import Prices*

Events in the floating exchange rate regime since 1970 have aroused considerable interest in the causal-effect relationship between exchange rate changes and prices. Over the years a quite significant number of studies have explored various means to analyze this relationship. Some of these studies demonstrate it graphically by illustrating the pass-through effects. Some have calculated the impact of exchange rate changes on prices directly from movements in import prices and exchange rates while others have employed more complete models that include exchange rates, a proxy for foreign costs, and other variables such as tariffs and capacity utilization.

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[15] In the pass-through nomenclature, the impact of exchange rate movements on over the dock prices of import is termed first stage pass-through while the consumer price response to changes in prices of imported inputs due to exchange rate changes is the second stage pass-through.

### *2.1.1. Graphical Illustrations of Exchange Rate Pass-Through*

A study by Kindleberger (1973) adopted a demand and supply framework to analyze the effects of a depreciation of the domestic currency on the prices and quantities of traded goods. The demand and supply curves represent quantities of exports and imports. Let us consider Canada and the United States for example. A depreciation of the Canadian dollar with respect to U.S. dollar will have no effect on the demand curve for imports measured in Canadian dollars but an upward shift in the supply curve of imports to Canada in terms of Canadian dollar because each Canadian dollar that U.S. exporters earn in Canada is now worth less in terms of U.S. dollars. However, this shift is not parallel; the distance between the original and the new curve represents a constant percentage change in the depreciation. Figure 2 captures the essence of Kindleberger's analysis on the equilibrium prices and quantities of traded goods.

Referring to figure 2, the equilibrium prior to depreciation in both cases is denoted by point ***e***. Canadian dollar depreciation shifts the supply curve to $S_m^{\,l}$ and eventually market forces drive the equilibrium point to $e_p$ while quantity falls. Kindleberger's main concern was to determine the conditions under which a change in the exchange rate would have maximum impact on the commodity prices. It is clear from figure 2 that price may be at *e*, $e_p$, $e_f$, or "in-between", depending on the slopes or the elasticities of demand and supply over the period.

***Figure 2: Supply and demand for imports and exports in Canadian dollar***

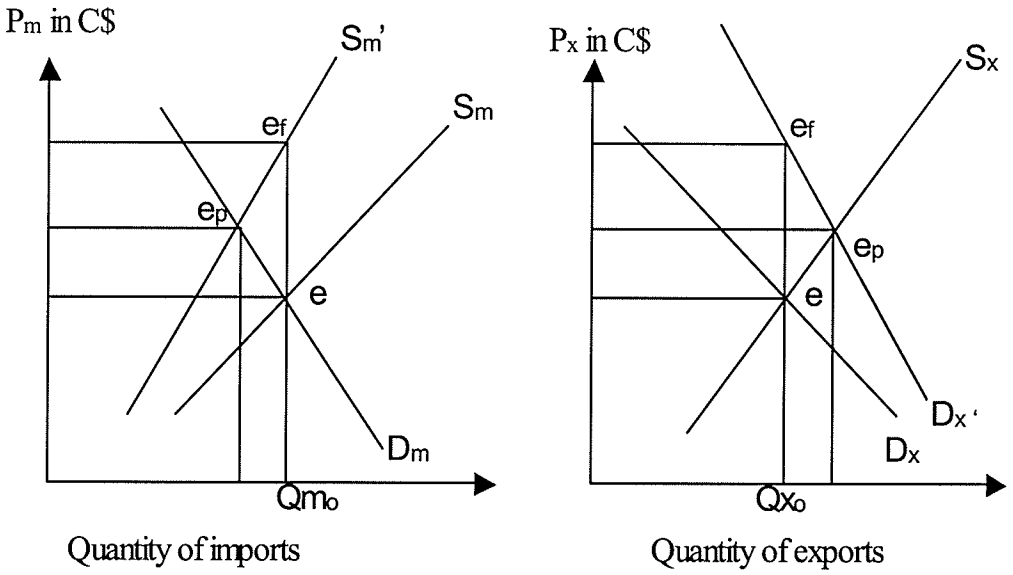


***Figure 2: Effect of depreciation on commodity prices:*** *In the left panel, $S_M$ is the US supply curve of imports to Canada expressed in Canadian dollars when the exchange rate is e, and $D_M$ is the Canadian demand curve for imports in Canadian dollar. With $D_M$ and $S_M$, equilibrium price is at point e and quantity of imports is $Qm_0$ units per year. If there is depreciation of the Canadian dollar, $S_M$ shifts up to $S_M^1$ but $D_M$ remains unchanged. With $S_M^1$ and $D_M$, equilibrium price of imports rises to point $e_p$ with reduction in quantity of imports per year. In the right panel, $D_X$ is the US demand curve for Canada's exports when exchange rate is e, and $S_X$ is Canada's supply curve of exports to the US both in terms of Canadian dollar. With $D_X$ and $S_X$, equilibrium price is at e and quantity of exports is $Qx_0$ units per year. When the Canadian dollar depreciates, $D_X$ shifts up to $D_X^1$ but $S_X$ remains unchanged. With $S_X$ and $D_X^1$, equilibrium price rises to point $e_p$ with an increase in quantity of exports per year. The effect of currency pass-through may be viewed as the vertical distance from e to $e_f$ in which quantities remain fixed at either $Qm_o$ or $Qx_o$.*

In this analysis, we can think of the pass-through divided into two-time periods: the short run and the long run. In the short run when quantities have not yet had time to adjust, pass-through may be complete since the domestic currency price of the imports could increase by the full amount of the depreciation. However, in the long run, after all adjustments have run their course, the excess supply ensures that the price falls sufficiently to restore equilibrium. Under the usual assumption of downward sloping demand curves and upward sloping supply curves, the long run pass-through effect will range between zero and unity.

Complete pass-through will occur only when demand for imports is perfectly inelastic or the supply of imports is perfectly elastic. In the case of a perfectly elastic demand curve or a perfectly inelastic supply curve, pass-through will be zero.

Magee (1973) examined the implication of pass-through for the very short-run when a goods exchange is already contracted. Currency-contract analysis deals with the impact of depreciation on the price of internationally traded goods that cross national boundaries after depreciation but that were contracted prior to the depreciation[16]. In a brief period following depreciation, quantities of imports and exports may be fixed. The constancy of quantities in that brief period may be due to the fact that trade contracts negotiated prior to the depreciation must be executed without changing their terms. In this case, supply becomes perfectly inelastic for a while because exporters cannot instantly alter their output or their sales abroad. Also, demand may be perfectly inelastic as well because importers require time to substitute among commodities and to change their flow of orders.

In figure 2, the effect of currency pass-through during the currency-contract period may be viewed as the intervals between $e$ and $e_f$ in which quantities remain fixed at $Qm_o$. Under the currency contract analysis, the crucial factor is whether the contract is denominated in foreign currency or in the domestic currency. For example, if all import contracts are denominated in Canadian dollars, a depreciation of the Canadian dollar will have no effect on the Canadian dollar price of imports, and equilibrium quantity and price remain the same at $e$. This means that foreign exporters now absorb either all the exchange rate risk or

[16] Magee, S. P., (1974) "US Import Prices in the Currency-Contract Period." *Brooking Papers on Economic Activities* 1: p.117

the cost of hedging. Conversely, if the contract is denominated in U.S. dollars, equilibrium prices would immediately jump to $e_f$[17].

Studies including Heller (1974) and Salvatore (2001) have also employed a graphical approach to analyze exchange rate pass-through. The conclusion drawn from such studies is that, while a depreciation of the domestic currency reduces the foreign currency price of domestic imports and exports, it increases the domestic currency price of imports and exports. It also stimulates the production of domestic import substitutes and exports. The rise in the prices of import substitutes and exports may be necessary to induce domestic producers to shift production from non-traded to traded goods.

While graphical analysis enables us to examine how market forces operate, it cannot be used to analyze the dynamic responses of the equilibrium variables vis-à-vis the speed of pass-through effects. Alternative analyses in the literature employed different from graphical models to estimate the degree of the pass-through effect and it is these theories that we turn to next. For analytical purposes, we divide the theoretical development into two time periods: i) from 1970 to 1980 (traditional theories) and ii) from 1980 to present (modern theories).

[17] The plotting of the effect on a nation's trade caused by devaluation of its currency is what economists termed the J-curve, because the trade balance worsens before showing improvement. Magee (1974 p.118) has observed that, the J-curve will always ensue if the proportion of contracts denominated in foreign currency is higher for imports than for exports.

### *2.1.2. Traditional Theories of Exchange Rate Pass-Through (1970-1980)*

#### *I. Elasticity approach*

The concept of elasticity has provided the foundation for theoretical advancement in international economics for many years[18]. The elasticity concept is not only useful in graphical analysis of exchange rate pass-through study but also it can be used to estimate the degree of exchange rate pass-through for the simple static model. The initial interest in the measurement of the pass-through effect started by the estimation of elasticities of import and export equations in international trade. Studies that employed elasticities approach derived import price equation as follows[19]:

$$\{2.3\} \qquad Q_D = D(P_D)$$

$$\{2.4\} \qquad Q_S = S(P_F / E) \quad \text{and} \quad P_D = P_F / E$$

where $Q_D$ and $Q_S$ represent the quantity demanded and supplied of the imported goods, $P_D$ and $P_F$ represent the domestic and foreign currency price of the imported good, and E represents the exchange rate, defined as domestic currency per unit of foreign currency. Differentiating *{2.3}* and *{2.4}*, we have:

$$\{2.5\} \qquad dQ_D = (dQ_D / dP_P)dP_D$$

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[18] Previous studies on concept of elasticity can be found in Kreinin (1967); Hendrik *et al.* (1969).
[19] We follow Menon's (1995) review of elasticity approach with slight modifications.

{2.6} $$dQ_S = dQ_S / dP_F[(1/E)dP_D - (P_{D/} / E^2)dE]$$

Setting *{2.5}* and *{2.6}* equal to each other in equilibrium, and denoting the elasticity of demand as $\varepsilon_D = (dQ_D / dP_D)P_D / Q_D$ and the elasticity of supply as $\varepsilon_S = (dQ_S / dP_F)(EP_D) / Q_S$, we have:

{2.7} $$(EQ_D / P_{D)}) / \varepsilon_S[(1/E)dP_D - (P_D / E^2) / dE] = Q_D / P_D \varepsilon_D dP_D$$

which simplifies to:

{2.8} $$PT = (dP_D / P_D) / dE / E) = (1 - \varepsilon_D / \varepsilon_S)^{-1}$$

Expression *{2.8}* 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 demand for imports is perfectly inelastic and supply is perfectly elastic, exchange rate pass-through will be complete.

Branson (1972), for instance, extended elasticity analysis to derive pass-through coefficients based on hypothetical elasticity values. Given a log-linear model with constant elasticities of demand and supply, Branson shows that the percentage change in the price of imports with respect to a given percentage depreciation can be expressed as:

{2.9} $$PT = 1 - \frac{1}{1 - \varepsilon_D / \varepsilon_S}$$

where $\varepsilon_D$ and $\varepsilon_S$ are the elasticities of demand and supply of imports. With this expression, Branson was able to show how changes in the exchange rate of large economies such as the United States could alter World prices, thus ensuring the co-existence of less than full or partial exchange rate pass-through. Magee (1974) who shares a similar view explains that a depreciation of the currency will be fully passed through to import prices when all inputs are imported and the demand curve is perfectly inelastic to price. In her studies, Lafleche (1996) noted that the nature of the product and the degree of product differentiation are the key factors that determine this elasticity. The more differentiated a product is, the less elastic its demand and the greater will be the impact of the exchange rate on its price.

Studies that applied elasticity approach to measure pass-through focused mainly on the aggregate outcome for individual countries (Magee 1973; Heller 1974; Kreinin 1977). The general conclusion is that, though the elasticities are known to vary among individual countries and over time, a small country which can be assumed to face an infinitely elastic supply of exports from its trading partners is likely to experience complete currency pass-through onto its domestic prices while only a partial pass-through can be expected with respect to the prices of a large country, which presumably faces an upward-sloping export supply curve.

The problem with measurement of pass-through based on the elasticity approach is that it does not provide any information on the speed or timing of the response of prices to exchange rate changes. There is a complete lack of information on how prices adjust from one equilibrium position to another. Besides, the measurement of pass-through based only on elasticity approach ignores what lies behind the supply responses of producers in different countries. It assumes that suppliers fully pass-through changes in exchange rates in the sense that supply curves fully rotate by the full percentage of the movement in exchange rate. While assumptions of upward-sloping supply curves and downward-sloping demand curves provide a new equilibrium price, which change less than the percentage change in the exchange rates (see figure 2), this assumption about supply responses is only acceptable for the case of perfect competition. With the rise of market imperfections, it is reasonable to assume that supply responses may vary with the degree of competition, the degree of substitutability between exports and domestically produced products, and the level of government regulation. The supply response will depend on the actual details of the industrial organization and of the technology of the industry (Venable 1990). As we shall see later, modern developments in the literature on imperfect competition and trade address both these issues.

### *II. The law of one price*

Traditional treatment of exchange rate pass-through begins with the assumption of law of one price, which states that identical products sell for the same common-currency price in different countries. If the law of one price holds for all countries for some product, then we say that world market is integrated. If the law of one price holds for all products

between two countries then the absolute version of PPP theory holds between these two countries such that[20],

$$\{2.10\} \qquad P_t = E_t P_t^* \tag{2.10}$$

where $P_t$ and $P_t^*$ are price levels of traded goods for domestic and foreign countries respectively, and $E$ is the exchange rate. Since the assumptions underlying the law of one price are unlikely to hold, economists often modify the absolute version of PPP to reflect factors that may prevent absolute PPP from holding. That is,

$$\{2.11\} \qquad P_t = kE_t P_t^* \tag{2.11}$$

where $k$ could be a measure reflecting transport costs, information costs or mark-ups. If $k$ remains constant over time, then common-currency prices for a particular product change in the same way over time in two countries, and the relative PPP holds. Estimation of exchange rate-price relationship requires that this model be solved for some kind of reduced form equation that expresses the price of imports in terms of a number of exogenous factors, which are observable. Tests of the law of one price usually employ a reduced form equation of the following generic type:

[20] The assumptions required for the law of one price to hold include profit maximization, costless transportation, distribution and resale. In this sense, the price of goods are geographically arbitraged and, adjusted for tariffs and transport costs.

$$\{2.12\} \qquad P_t^m = k + \beta E_t + rX_t + gR_T + \mu_t$$

where all variables are in logarithm form, $P^m$ is the price of a particular imported product, $E$ is the exchange rate, $X$ and $R$ denote control variables in a particular model, $u$ is an error term and t denotes time period. Exchange rate pass-through is "full" or "complete" if there is one-for-one response of log import prices to log of exchange rate. This analytical framework accommodates various models that seek to determine the validity of the law of one price. Distinctions among them arise from the specific price *(P)* series selected as the dependent variable and the choice of independent variables $X$ and $R$ that are included in addition to exchange rate in a particular model (Rogoff 1996; Goldberg and Knetter 1997).

Unfortunately, studies that tested for various versions of the law of one price have come to conclude that complete equalization of prices may be implausible. Economists have questioned the validity of the assumptions of PPP theory. Arbitrage is not costless; there are costs of gathering information, transporting goods and perhaps crossing borders. The identical goods assumption has also been questioned. There is general consensus in the literature that changes in exchange rate are not always fully passed through to prices of traded goods. Most studies have rejected the fundamental tenet of purchasing power parity for both short-run and long run time span as an adequate theory for exchange rate pass through relation[21].

[21] The literature on law of one price or PPP is enormous. On the criticisms of PPP, see Officer (1976), McKinnon (1979), Isard (1977, 1987) Fraser *et al.* (1990), Michael *et al.* (1994), Rogoff *et al.* (1995), Gibson (1996).

### *III. Control country approach*

An early study of exchange rate pass-through noteworthy for its methodology is Kreinin's (1977) paper. Whereas the standard model uses regression analysis to control for other factors, Kreinin employed what is termed "control country approach" to analyze the pass-through effect of exchange rate adjustments. In some sense, this approach fulfils the role of economic modeling in holding all other factors constant. Kreinin defines exchange rate pass-through as the difference between the change in prices that actually has taken place and the hypothetical change that would have occurred in the absence of exchange rate change[22]. The hypothetical price change in his investigated country is inferred from the average change that actually occurred in the *control country,* country c. The ideal control country should be similar in all or most respects to the country with which the control country is being compared except that its exchange rate did not change.

Given the percentage change in the prices of country *k's* imports from country *i* as ${}_i\dot{P}_m^k$ and the percentage change in country *i's* exchange rates relative to country *k as* $\dot{E}^k$, the pass-through relation for any country *k* whose currency depreciated with respect to country *i* can be stated as:

*{2.13}* $${}_i\dot{P}_m^k = \beta \cdot {}_i\dot{E}^k$$

[22] Kreinin (1977) "The Effect of Exchange Rate Changes on the Prices and Volume of Foreign Trade". *IMF Staff Paper* 24: p.302.

Thus, the percentage change in the prices of country $k$'s imports from country $i$ is a fraction $(\beta)$ of the percentage change in country $i$'s exchange rate relative to country $k$, where $(\beta)$ is the measure of the pass-through and $E$ is exchange rate defined as the unit of $k$ (domestic) currency per unit of the $i$ (foreign) currency. By considering the percentage change in the prices of the country $k$'s imports from the control country $c$, ${}_c\dot{P}_m^k$, as a proxy for what ${}_i\dot{P}_m^k$ would have been the case in the absence of exchange rate adjustment, Kreinin expressed the degree of pass-through effect $(\beta)$ as:

$$\{2.14\} \qquad \beta_i = \frac{{}_i\dot{P}_m^k - {}_c\dot{P}_m^k}{{}_i\dot{E}^k} \cdot 100$$

Like any other theory, the control country approach is not without drawbacks. One of the significant points that limit its usefulness is the selection of a control country deemed similar in all respect to the investigated country. For instance, Kreinin assumes Finland to be similar to the United States while in most respects it is not. Besides, it does not indicate the speed and the timing of pass-through effect. Clearly "neither" the simple purchasing power parity relations, the elasticity approach nor the control country approach alone can provide an adequate explanation for observed pricing behavior in recent years. This has influenced the recent direction of theoretical and empirical research by both international finance and international trade economists on the relationship between exchange rates and firms' pricing policies for internationally traded goods.

### *2.1.3. Modern Theories of Exchange Rate Pass-Through: 1980-Present*

The theoretical explanations of pass-through now emphasize the role of market structure, followed by product characteristics to explain incomplete pass-through. These models have been concerned with explaining whether the empirical data on pass-through merely reflects short-run squeezing of profit margins by exporters, or if particular type of market organization always leads to only a limited response of prices to exchange rate changes.

#### *I. Industrial organization models*

The rise of market imperfections and product differentiation has led researchers to estimate pass-through effects for markets with different organizational structures. Manufactured goods are typically viewed as being highly differentiated and frequently sold in imperfectly competitive and segmented markets where arbitrage is costly[23]. Under the condition of imperfect competition, pricing will no longer be at marginal cost. Producers would be in a position to charge a mark-up on costs to earn above normal profits even in the long run. The critical question is how much mark-ups over marginal cost will vary in response to an exchange rate change? Economists have identified at least two factors that can influence the level of markups charged over costs (Menon 1995 p.200): (i) the degree of substitutability between the domestic and imported goods, as determined by the degree of product differentiation and (ii) the degree of market integration or separation (Krugman 1986; Dornbusch 1987; Fisher 1989). Both these factors can be considered as forces that come to play in determining the price-setting power of firms, and will influence the behavior of firms in responding to exchange rate changes.

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[23] Product quality and attributes, brand name and even packaging and warranty can differentiate one product from others.

Dornbusch (1987) studied the effect of short-term exchange rate changes in several different models of industrial organization. In particular, Dornbusch extended Dixit-Stiglitz's (1977) model and Salop's (1979) model of imperfect competition to explain the effect of imperfect substitutability and product differentiation on the price response to exchange rate changes. Each of these pricing models is based on the notion that price adjustments result from changes in relative unit labor costs. The basic assumption is that technology is linear with only labor as an input. He also assumes that wages are constant throughout the adjustment period. Based on these assumptions, Dornbusch considers strategic pricing interactions by means of conjectural variations. The pricing policies therefore become:

*{2.15}*
$$p = \left( \frac{\eta(1-\varepsilon)}{\eta(1-\varepsilon)-1} \right) \frac{W^*}{e}$$

where p = price in domestic currency

$\eta$ = elasticity of demand

$\varepsilon = (\partial P / P) / (\partial P_t / P_t)$, the elasticity of aggregate industry price with respect to the price of the competitor

$W^*$ =unit labor costs in foreign currency

e = exchange rate .

Note that the exchange rate is defined as foreign currency per unit of domestic currency

Dornbusch illustrated both mathematically and graphically, how foreign firms lower their currency price less than proportionally to the reduction in their currency unit labor costs. The common feature of all the models is that they all predict that an appreciation should lead to a decline in the price of imports. Whereas domestic firms would fully match the changes in prices for homogeneous products, it will always be the case that the relative prices of the imported brands will increase in response to depreciation if products are differentiated. However, the extent of the increase will depend on a measure of competition and on the relative number of home and foreign firms.

The microeconomic questions of how market concentration and how different assumptions about the behavior of firms affect the pass-through relation have also received attention in the industrial organization literature. Under the floating exchange rate regime, it would be prohibitively expensive for most manufacturers to change their offer prices with every movement of the value of foreign exchange (Fisher 1989 p.120). However, through the strategic interdependence of producers' decisions, exchange rate changes can give rise to import price changes but the degree of pass-through may not be uniform across industries that have different competitive structures. It may depend upon the degree of market concentration or the nature of the industry vis-à-vis the nature of the product.

Fisher (1989) employed partial equilibrium analysis to examine how market concentration affects pass-through. This model incorporates the idea that producers set prices in anticipation of exchange rate changes and build upon the premise that effects of exchange rate changes are quite different in the short run from what they are in the long run. His

analysis of an oligopolist industry shows that both exchange rate expectations and realizations matter for its equilibrium but the realization of a large depreciation of the domestic currency matters less than oligopolists' expectations about how the domestic currency will move during the course of their planning horizon. In the same study, Fisher considers a case where firms are Bertrand competitors 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.

Venable (1990) and Dornbusch (1987) in a separate study consider a case of a Cournot industry with a linear demand curve and constant costs to show that the degree of pass-through is a positive function of the ratio of the number of foreign firms to total firms. They also show that a firm's mark-up on marginal cost in determining its prices is an increasing function of its market share. In a Cournot setting, each firm is assumed to choose its sales in the domestic market given the sale of the other firms, with price determined from the demand curve. The profit of the $n^D$ domestic firms is given by

$$\pi^D = px^D - C^D x^D \qquad \{2.16\}$$

and the $n^F$ foreign firms:

$$\pi^D = px^F - EC^F x^F \qquad \{2.17\}$$

where $x^D$ and $x^F$ are the output of the domestic and the foreign firms, and $C^D x^D$ is the cost function of the domestic firms. Profit maximization by each firm given the output of other firms yields the following first-order conditions for the domestic and foreign firms:

*{2.18}* $$p[1 - x^D / (\varepsilon_D X)] = C^D$$ and

*{2.19}* $$p[1 - x^F / (\varepsilon_D X)] = EC^F$$

By denoting the market shares of each individual domestic and foreign firm as $m^D$ and $m^F$, we can re-write equations {2.18} and {2.19} in the following manner for the domestic firm

*{2.20}* $$p(1 - m^D / \varepsilon_D) = C^D$$

and the foreign firm,

*{2.21}* $$p(1 - m^F / \varepsilon_D) = EC^F$$

where $C^D$ and $C^F$ represent the marginal cost of domestic and foreign firms respectively. It could be seen from equation {2.20} and {2.21} that the firm's mark-up on marginal cost in determining its prices is an increasing function of its market share. It is clearer when we consider pure monopoly and perfect competition, where m is 1 and close to 0, respectively.

To determine the equilibrium price in the market, we combine price setting behavior of both domestic and foreign firms given by

$$p = \varepsilon_D \left\{ \frac{n^D C^D + n^F E C^F}{\varepsilon_D (n^F + n^D) - 1} \right\} \qquad \{2.22\}$$

Note that the sum of market share equals one, i.e ($n^D m^D + n^F m^F = 1$). Expression (2.22) posits 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, E, affects only the foreign firms, it is clear that there will be less than full pass-through. Given that the marginal costs are constant and that foreign and domestic costs are equal, we can express pass-through relation in terms of number firms as follows:

$$PT = \left\{ \frac{n^F}{n^F + n^D} \right\} \qquad \{2.23\}$$

In expression *{2.23},* it can be argued that an equal number of domestic and foreign firms will result in a pass-through of 50 percent whereas pass-through will be about 67 percent if there are twice as many foreign firms as there are domestic firms.

### *II. Mark-up models*

One of the most insightful studies in this group of models is a study by Hooper and Mann (1989). The Hooper-Mann model extends Mann's (1986) markup analysis to estimate the timing and the magnitude of the effect of changes in the exchange rate on import prices.

The analysis focused on the narrow definition of pass-through as the partial derivative of the log of import prices with respect to log of the nominal exchange rate. In that sense, the model allows import prices to relate other relevant variables such as foreign costs and capacity utilization. As we shall see later in chapter 4, the model provides an intuitively appealing and attractive version of why we observe partial exchange rate pass-through. Besides, its simplicity in empirical work has attracted several other authors to use it to explore similar areas. Melick (1990), for instance employed it to estimate pass-through coefficients and subsequently tested for exchange rate parameter stability. Athukorala (1991) also adopted the Hooper-Mann model to discern the relationship between exchange rates and prices of manufactured exports from Korea. He estimates the following regression for several aggregate categories of manufactured goods:

$$\{2.17\} \qquad px_t = A + \sum_{i=0}^{k} \theta e_{t-1} + \chi p^d{}_t + g d^p{}_t + \varphi cp_{t-1} + \varepsilon_t$$

where $px$ = export price in *won*

$e$ = exchange rate quoted in *won*

$p^d$ = competitors price measured in destination currency

$d^p$ = demand pressure (capacity utilization)

$cp$ = unit production cost

when prices in the exporting currency are the regressands, pass-through coefficients ($\beta$) becomes,

{2.18} $$\beta = 1 - \sum_{i=0}^{k} \theta$$

Athukorala argues that the competitiveness of Korean export markets is reflected by the value of "*beta*". If Korean exporters are essentially price takers (in foreign currency), changes in the exchange rate would translate into an equal change in the won price of exports, leaving the price valued in foreign currency unchanged; thus $\beta$=1. On the other hand, as the market power of Korea exporters increases, $\beta$ approaches 1. A study by Khosla (1991) also employed the Hooper-Mann approach to analyze the effect of exchange rate fluctuations on the yen price of Japanese exports. His analysis reinforces the notion that homogeneous products have a lower pass-through than differentiated products.

Dwyer and Lam (1995) also invoke mark-up model to explain dynamics of adjustment of import prices to changes in the exchange rate. While the majority of the pass-through studies concentrate on import price response to exchange rate, Dwyer and Lam divide pass-through relationship into two stages. The first stage pass-through is defined to be the elasticity of the domestic over-the-dock import price with respect to the exchange rate while second stage is the elasticity of a retail import price with respect to over-the-docks import price. Employing a simple mark-up model, retail price is determined by the total costs facing the distributor and a mark-up, where total costs comprise the cost of the import itself and the cost of domestic inputs used in the process of distributing and selling the import. Their exposition for the first stage follows the law of one price (see expression 2.10) by allowing the foreign import price to embody a mark-up ($k$) so that we have identity

*{2,19}* $$P^{m^*} = (C^* k^*)$$

By substituting expression *{2.19}* in *{2.10}* we have the first stage pass-through as

*{2.20}* $$P^m = (C^* k^*)E$$

The second stage pass-through was defined as

*{2.21}* $$P^r = P^{\alpha} C^{(1-\alpha)} k$$

Expressing the elasticity of a retail import price with respect to over-the-docks import price yields,

*{2.22}* $$\frac{dP^r / P^r}{dP^m / P^m} = \alpha$$

Where $P^r$ is the domestic import price defined as a final retail price, and $\alpha$ represents the share of the import in total cost. Equation *{2.22}* expresses second stage pass-through as the share of the imported item in the total cost faced by the retailer. At a given cost, the retailer of an import can elect to offset the effects of an increase in $P^r$ by lowering its mark-up so that second stage pass-through is incomplete. To trace the full impact of an exchange

rate change on the retail import price, the first and second stage pass-through can be combined as follows,

*{2.23}* $$P^r = [k^* C^* E]^{\alpha} C^{(1-\alpha)} k$$

In equation *{2.23},* it is clear that the effect of an exchange rate change on the retail import price of an import can be diffused through three main channels: the size of share of import in total costs, $\alpha$, variations in the mark-up by foreign suppliers, and variation in the mark-up of local distributors. While this model amply demonstrates the existence of incomplete pass-through, it does not account for circumstances under which mark-ups are altered.

Much work in recent years has examined the issue of markup adjustment and the extent to which import prices respond to changes in foreign costs induced by exchange rate change. This research has also revealed that the percentage change in the price of imported goods is smaller than the percentage change in exchange rates of the exporting country. The interesting revelation of these studies is that price responses differ across different destinations, giving rise to what Paul Krugman termed "pricing-to-market" These studies point to the failure of the law of one price for manufactured goods and also suggest the existence of incomplete pass-through and market imperfections in international trade.

For pricing-to-market to occur, a firm must have market power that gives it discretion in setting prices. Models explaining price-to-market begin with the assumption that export markets are segmented with limited opportunities for arbitrage. A product market is

geographically segmented if the location of the buyers and sellers influences the terms of transaction in a substantial way (i.e by more than the marginal cost of physically moving the good from one location to another, (Goldberg and Knetter 1997). When a market for traded goods is segmented, supplier countries, in pricing their exports, may have the incentive to discriminate among their customers. In a particular instance of depreciation, if a destination country features prominently in the sales, suppliers may lower their selling prices to forestall some of the expected reduction in sales. There is considerable amount of theoretical evidence in the literature to support these views about manufactured imports. Pricing-to-market literature blends the microeconomic foundations of exchange rate pass-through research and studies of multiple transactions in different market environments.

A study by Spitaller (1980) analyzes short-run effects of exchange rate changes on terms of trade and the trade balance. In that paper, Spitaller attempted to capture the magnitude and short-run time path of the effects of exchange rate changes on import prices[24]. His estimated short-run exchange rate effects on export unit values suggest that the change in competitiveness due to a given movement in the exchange rate tends to affect the exchange rate impact and differ among countries. In most instances, the effect is smaller than the amount of the exchange rate change and occurs relatively slower (Spitaller 1980 p.342).

Knetter (1989) investigates whether U.S. and German firms price discriminate across various export markets. He estimates marginal cost and mark-ups for these firms. He finds

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[24]Spitaller employed a simple structural model composed of demand and supply equations for a country's imports, as well as an equilibrium condition and an expression of total factor costs in the production of imports in terms of material inputs.

that pricing-to-market is possible because firms charge different prices in different markets. Krugman (1987) classifies pass-through models as either static or dynamic. In static models, firms can price-to-market because they can practice price discrimination across their domestic and export markets. Dynamic models, by definition, have multi-period effects on the demand or the supply side. Krugman argued that "reputation" effects particularly on the demand side, could constrain firms from passing through every fluctuation in the exchange rate. Froot and Klemperer (1989) observed that, there may be other forms of intertemporal effects in demand, e.g., brand loyalty on the part of consumers, network externalities, switching costs, multi-period pricing and advertising effects, any or all of which can cause incomplete pass-through.

On the supply side, Kasa (1992) notes that supply relationship can have an element of adjustment costs or capacity constraints that cause price stickiness, especially if the exchange rate fluctuation is either unanticipated or expected to reverse. On his part, Dixit (1989) explained that it might not be reasonable for firms to expand their production and overseas sales and distribution networks in response to every movement of the exchange rate. There may be substantial costs of entry, expansion and exit that force producers to absorb exchange rate fluctuations in their mark-ups instead of passing them on to the import price as exchange rate changes.

A related question asks how much price discrimination in the presence of pricing-to-market is deliberate on the part of the producers, and how much is because of unexpected exchange rate movements. Marston (1990) separates the two effects and concludes that

even after allowing for exchange rate surprises, there is still strong evidence to support deliberate pricing-to-market. Marston's markup model concentrates on pricing-to-market behavior by eliminating the portion of incomplete pass-through attributed to exchange induced cost shock. By taking the ratio of a firm's export price to domestic price, the common portion of marginal costs cancel each other out. Mathematically, we can express the result of his derivations as,

*{2.24}*
$$\frac{ep_x}{p_d} = \frac{\mu}{1-\mu} \cdot \frac{\varepsilon - 1}{\varepsilon}$$

where e = exchange rate

$p_x$ = foreign currency export price

$p_d$ = domestic price

$\mu, \varepsilon$ = price elasticity of demand in the export and domestic market respectively

Given the specification of his profit function (not shown), the markup ratio is a function of real prices and real income in each market. Total differentiation of first order conditions gives price-to-market elasticities between 0 and 1 when markups are variable and demand curves less convex than constant elasticity demand curves. His major contribution centers on the ability to detect changes in the export price to domestic price ratio due to exchange rate "surprises" (i.e unanticipated changes in the exchange rate). If firms preset their prices in foreign currency, Marston shows that nominal exchange rate surprises will have an

effect on profit margins, albeit temporary, until firms have the opportunity to change prices.

A desire to maintain market share may lead firms not to change prices in response to every movement of the value of the exchange rate[25]. A study by Froot and Klemperer (1989) analyze pricing strategies that aim to protect market shares, and how temporary versus permanent exchange rate changes come to bear on this decision. This was done by employing a simple two-period model where market share in the first period will affect the price response to an exchange rate change in the second period. Their analysis shows that foreign firms may be reluctant to increase prices by the full amount of the exchange rate depreciation if they are not convinced that the depreciation of the currency will persist and not be reversed in the near future. Since it is very costly to plan and build or dismantle production facilities and enter new markets, they do not want to risk losing their market share by a large increase in the price of their products.

A similar study by Gagnon *et al.* (1996) extended the Bertrand differentiated products model to examine the relationship between exchange rate pass-through and market share. The main result is that pass-through tends to be highest when a group of source country exporters has a very high market share. When market share is very high, the individual firms from a particular source country face little competition, and thus will more fully pass through an exchange rate change for a given market demand schedule. According to

[25] Market share is defined to be the export country's share of total sales in a particular destination market.

Gagnon *et al.,* pass-through rises with market share at an increasing rate as share becomes larger. Marston's (1990) analysis in equation *{2.24}* indicated particularly that Japanese firms during most part of 1980s altered their profit margins (or markups) in order to remain competitive in the U.S. market.

The rise of imperfect competition and strategic trade theory has led researchers to estimate exchange rate pass-through at the industry level. These studies estimate price-cost margins from market outcome data that is critical to identifying the exact degree of pass-through. Besides, they estimate the underlying market structure and conduct of firms in the industry, incorporating industry- and firm-specific features into econometric modeling of firm and consumer behavior in the industry. These features enable one to identify the source of pass-through, i.e. to separate demand, cost, and market structure explanations of pass-through. The industrial level analysis is illustrated in studies such as Feenstra (1989), Goldberg (1995), and Kadiyali (1997).

Feenstra (1989) shows that the first-order conditions for a monopoly selling to a foreign market imply that there is a symmetric response of import prices to changes in the exchange rate and an import tariff[26]. He asserts that exchange rate pass-through studies would have implications for trade policy if the symmetric restrictions were to be supported by empirical evidence. Using the U.S. import unit values from Japan as a measure of price

[26] Feenstra examined the effect of tariffs and exchange rate changes to see whether long-run pass-through of tariffs and exchange rates are symmetrical or identical.

for three separate industries: cars, compact trucks and heavy motorcycles, Feenstra estimates pass-through equations by regressing the prices of the importing firm on the regressors that include a time trend to capture quality change, a demand shifter, a measure of competitiveness, a measure of cost of production and ad valorem tariff rates. His equations give a measure of how demand, supply, and competition affect the import price, and hence the degree of pass-through.

Goldberg (1995) estimates firm-level mark-ups, and hence firm-level pass-through for the U.S. automobile industry. She imposes a Bertrand specification on interactions of firms in the industry. Kadiyali (1997) studied the U.S. photographic film industry. He builds a model in a "new empirical industrial organization" framework to estimate exchange rate pass-through in prices. Price-cost margins, market structure and firm conduct were estimated endogenously, allowing for precise estimation of the degree of, and reasons for, incomplete pass-through. Kadiyali demonstrated that price and advertising pass-through are functions of demand, cost and market conduct in the short run. In the long-run, market conduct and cost technologies are in turn, determined by exchange rate movements.

Another consideration relates to how the nature of exchange rate movements affects the degree of pass-through. Studies on this issue use dynamic models of pass-through. Kasa (1992) shows that firms are more likely to respond to large, permanent exchange rate changes than to changes that are small and temporary. If exchange rate change is large and permanent, a firm may respond by changing its export price, expanding or contracting

production and distribution. In the case of a small and temporary change, its response may be to absorb changes in its product mark-up rather than to adjust price.

### *III. Hysteresis models*

Hysteresis is a concept taken from natural sciences. Hysteresis produces a certain non-linearity where the relationship between two or more variables crucially depends on past history[27]. In the economic realm, the term hysteresis has been interpreted to represent any effects that remain after the initial cause responsible for the effects has been eliminated (Baldwin 1988; Krugman 1989; Ohno 1990). The hysteresis effect posits that relationships between variables are a function of the past (i.e they are path dependent). The existence of hysteresis in imperfectly competitive markets combined with various degrees of time preference influences pass-through and the trade pattern in the floating exchange rate regime.

The hysteresis models are often built on the notion of irretrievable sunk costs associated with entry-exist decisions in world markets. They are based on the idea that the volatile climate of floating exchange rates has induced firms to adapt a *"wait and see"* attitude (Menon 1995). Studies that took into consideration hysteresis effects have shown that firms are less likely to enter a market following a temporary and small exchange rate change if there are significant sunk costs involved (Baldwin 1988). Thus, the presence of sunk costs ensures market structure stability in the face of small exchange rate changes.

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[27] The term "hysteresis" was first suggested by the Scottish Physicist James Alfred Ewing whose work on the behaviour of electromagnetic properties of ferric metals produced curves which exhibit, in a sticking manner, a persistence of previous states [Ewing 1881: 22]

The hysteresis effect suggests that competition in the market will remain unchanged as long as exchange rates fluctuate within a set band, and that, this band will be greater the higher the costs associated with entry and exist. This often results in a low rate of pass-through as firms fight to either stay in the market or deter entry.

In their attempt to explain the persistence of the U.S. trade deficit inspite of the large depreciation of the U.S. dollar in 1985, Krugman and Baldwin (1987) allude to the notion that large sunk costs can contribute to persistent effects on market structures once the exchange rates return to pre-shock levels. In turn, changes in the general competitiveness of an industry will affect the exchange rate pass-through. While most researchers focus on hysteresis on quantity, Baldwin (1988) extends the theoretical literature to include price hysteresis. His beachhead or sunk cost model assumes that firms engage in Cournot competition and the entry decision is based on the sum of current and expected profits exceeding the original sunk costs plus operating costs associated with each subsequent period. The resulting markup model estimation takes the form:

*{2.25}*
$$p_t = \alpha\{\varepsilon m_t\} + \sum_{1=0}^{\infty} \beta(c^* e)_{t-1}$$

where $p_t$ = price in dollars

$\varepsilon$ = price elasticity of demand

c*= marginal cost in foreign currency, $m$ = total number of firms

e =exchange rate (domestic/foreign), all variables are in logs

His estimated result finds structural break in the import price equation. Unfortunately the evidence of structural breaks does not imply acceptance of Baldwin's beachhead model. Clearly, factors other than hysteresis may contribute to structural break. Baldwin also admitted that the once-and-for-all effect of large exchange rate movements on prices of traded goods might have no influence on the true exchange rate pass-through coefficient *($\beta$)*.

Ohno's (1990) paper combines the corporate planning horizon with the existence of hysteresis to account for the different degree of pass-through exhibited by Japanese and the U.S. exporters during the large dollar fluctuations in the 1980s. Ohno noted that when exchange rate fluctuates and the market exhibits hysteresis, planning horizons of domestic and foreign competitors would matter in the determination of pass-through as well as relative market shares of these firms. His simulation using the Cournot duopoly model shows that the degree of pass-through is inversely related to the length of a firm's planning horizons. In other words, firms with planning horizons oriented towards the long run will select pricing policies, which lead to lower pass-through coefficients and higher market share (Ohno 1990 p.308).

### *IV. Multinational corporation (MNC) strategies*

The instability in foreign exchange rate markets, and in particular the large swings in the exchange rate movements which have come to characterize the floating era, have induced MNCs to actively employ intra-firm pricing policies which, according to Menon (1995a), prevent the full transmission of the exchange rate changes to import prices. There exist a number of ways in which MNCs can shield themselves against exchange rate uncertainty.

In that spirit of unfavorable exchange rate shocks, Menon highlights three strategies available to MNCs, which can reduce the risks associated with uncertainty and unfavorable shocks. First, he cites evidence of widespread use of "internal exchange rates" for intra-firm transactions. The use of internal exchange rates enables foreign affiliates to insulate their pricing decision from large exchange rate fluctuations. 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. These rates can also be manipulated to reflect global decisions relating to pricing and the absorption of exchange rate changes. Evidence suggests that the use of intra-corporate exchange rate is widespread among MNCs operating in Australia, and that its use is designed primarily to guard against unfavorable price consequences of large exchange rates movements[28]. PSA (1989) noted that the widespread use of these internal exchange rates have severely weakened the link between exchange rate changes and import prices.

Second, MNCs frequently provide flexible internal credit arrangements for affiliates who face considerable exchange rate volatility. By prolonging the timing of payments until a more favorable exchange rate returns, the link between an affiliate's pricing decision and current exchange rate is further reduced. Third, the choice of currency denomination for intra-firm transactions will also affect pricing decisions (Menon 1995 p.205). The MNC literature seems to support the view that the practice of intra-firm pricing policies has facilitated the stabilization of prices in domestic markets, and allowed subsidiaries of

[28] Price Surveillance Authority (PSA) (1989) "Inquiry into effects of exchange rate appreciation on the prices of consumer goods", Report No. 21. Canberra: Australia Government Publishing Service.

MNCs to avoid significant loss of market share following large exchange rate depreciations. Economists have found that there is considerable scope for payment adjustments in the internal transactions of multinational firms and that they generally have more room to maneuver (Grassman 1973).

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-market independently of current exchange rates (Helleiner 1985; Mirus and Yeung 1987). Holmes (1978) 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. Dunn (1970) provides evidence of MNCs employing their sales subsidiaries to facilitate similar pricing strategies in Canada. Carse *et al.*(1980) find that flexible methods of settlement are confined almost exclusively to intra-MNC trade, with credit terms twice as long as for independent firms. They conclude that the degree to which such arrangements are exploited depends on the circumstances facing the firm and it is this flexibility that enables the MNC to use it as a decision variable. Menon (1993) reports that, 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 whereby exchange rate fluctuations that occur in the interim can effectively be bypassed.

Notwithstanding the leverage available to the MNC and the flexibility in the methods of settlement, the volatile climate of floating exchange rates still 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 in order to remain competitive in export markets.

### *2.2. Exchange Rate Changes And Consumer Prices*

Most investigations of exchange rate pass-through have focused only on the transmissions of exchange rate changes to import prices. However, it is the retail price of an import, and not that over the docks, that directly enters measured inflation. Understanding the price adjustment as imports are distributed to local markets is central to any assessment of the general price impact of currency depreciation. As already established, movements in the exchange rate have an impact on the prices of imported goods and inputs. Through these price changes, there can also be either direct or indirect effect on retail selling prices. The consumer price response to changes in prices of imported inputs caused by movements in the exchange rate depends not only on the share of imported inputs in production but also on other factors such as demand conditions, the cost of adjusting prices, and perceptions as to the duration of the depreciation. It also depends on the competitive structure of the industries in the domestic economy that depend heavily on imported inputs.

#### *2.2.1 Impact of Depreciation on Domestic Firms*

The firms most affected by an unexpected depreciation of the exchange rate are usually those domestic producers that deal with differentiated or heterogeneous products [29]. A market is said to have heterogeneous or differentiated products when consumers view the

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[29] Lafleche (1996 p.23) analyzed the impact of exchange rate changes on individual firms and the extent to which these changes influence consumer prices within the context of production models.

products of the various producers as being somewhat different from one another. Such differences may stem from product quality and attributes, brand name and packaging, services, location and warranty. This type of market is referred to as a monopolistic competitive market. Consumer goods are generally traded in the market environments that are characterized by monopolistically competitive behavior. In McConnel, Brue and Barbiero (1999 p.268), identification of sectors that approximate monopolistically competitive conditions include wholesale or retail stores in metropolitan areas, grocery stores, gasoline stations, barbershops, clothing stores, restaurants etc.

The basic feature of this type of market is that each firm faces a highly, but not perfectly elastic demand structure that is unique to its own product and that each firm has some degree of freedom to adjust its prices. With such a market behavior, a depreciation of the domestic currency causes a rise in production costs for a firm or producer that imports all or major portion of its inputs over which the firm usually has no control. With some degree of control over the prices of output and hence profit margin, a firm that depends on imported inputs may pass through higher prices to the consumer when the home currency depreciates. Faced with higher costs of production, if demand remains constant or does not increase then the firm will cut back its production and raise its prices[30].

Feinberg (1989) has drawn on models of industrial organization to explain the links between exchange rate changes and retail consumer prices. His major focus was on the issue of whether domestic industries differ systematically in their response to exchange

[30] The degree of control that a firm enjoys over the price of its output, and thus its profit margin is a key factor in the pass-through of higher import (input) prices to the consumer.

rate changes. Feinberg concludes that, changes in the external value of the domestic currency would be passed most fully into domestic prices by industries heavily reliant on imported inputs and producing goods highly substitutable for imports. If the increase in demand for domestic firms dealing with import substitutes is so large that output has to become higher than it was before the depreciation, then the total increase in the domestic prices will be greater than the increase in production costs stemming from the depreciation. On the other hand, if the imported goods are highly differentiated relative to their substitutes, or if there are no domestic substitute products, the exchange rate effect on consumer prices will also be more pronounced.

### *2.2.2. Adjustment Costs Models*

Costs of adjusting prices also influence the extent and the speed through which exchange rate changes affect retail-selling prices. This view is based on models of price adjustment. Studies by Amano and Macklem (1997) apply a menu-cost model of price adjustment to show how relative price shocks affect consumer prices[31]. According to this model, if firms face costs in adjusting prices, firms will change their actual selling price only if the desired adjustment is large enough to warrant paying the adjustment or menu cost. This implies that firms will not change their prices unless the losses incurred by leaving them unchanged exceed the adjustment costs. As a result, firms may respond to large shocks but not small ones, which imply that large shocks will have a disproportionate effect on the price level and thus on inflation in the short run[32].

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[31] The analysis followed focused on relative price shocks induced by domestic currency depreciation that affects imported inputs.

[32] Amano and Macklem (1997) "Menu Costs, Relative Prices, and Inflation: Evidence for Canada." *Bank of Canada Working Paper* 97-14: June 1997

In a classical version of price adjustment model that assumes perfectly flexible prices, relative price shocks that affect inputs should lead some firms to increase their nominal prices and others to decrease them, leaving the aggregate price level unchanged. That is, if nominal incomes do not rise and prices of some goods rise as a result of relative-price increase, consumers will be left with less income to buy other goods so that the demand for such goods and hence their prices will decline leaving the average levels of general prices in the economy unchanged. For various reasons, prices of many goods are not perfectly flexible as most firms face costs of adjusting prices. In the presence of price-adjustment costs, only firms whose desired price adjustment is greater than some critical value will in fact change their prices[33].

The implication is that a large increase in the prices of imported products induced by exchange rate depreciation may lead some firms that use imported goods as an important input in production to increase their prices considerably. With perfectly flexible prices, these increases would be balanced by small price declines in the prices of other goods. But in the presence of price-adjustment costs, only firms faced with a large increase in their price will in fact adjust their price, while firms experiencing small changes, either increases or decreases, will leave their prices unchanged. The net result will be a rise in general prices.

In relation to costs of adjusting prices, the uncertainty about the nature of the depreciation also influences the degree and the speed with which exchange rate changes affect

[33] *Ibid*

consumer prices. If the firm believes that the depreciation is temporary, it may choose to change neither its prices nor its output, since a subsequent appreciation of the currency would return the firm's costs to its original level. While this decision will mean a temporary squeeze on profit margins, savings from avoiding adjustment costs will offset it. However, if the firm thinks that the depreciation is likely to be permanent, or that it will last long enough to affect future management decisions, then it will adjust its prices and production fairly quickly. If it takes some time before the firm realizes that the depreciation is permanent, the price increase will occur only with a certain lag. The possibility of hedging foreign exchange exposure on the forward market may also contribute to the lagged effect of the exchange rate changes on production costs and, consequently, on consumer prices.

### *2.2.3. Impact of Depreciation Through Wages And Salaries*

Exchange rate depreciation has an indirect impact on general price levels through inflationary expectations and their attendant pressure on wages and salaries (Caramazza 1986; De Brouwer, Ericsson and Flood 1994). Depreciation-induced increases in selling prices will be partially reflected in higher nominal wages and salaries for those workers with cost-of-living adjustment (COLA) clauses in collective agreements. Other workers whose wages and salaries are not indexed will also find that the real value of their earnings is being eroded and may demand higher money wages to protect past wage gains and possibly to offset expected future inflation. Besides, the increased demand for the export and import-competing industries and the associated stimulated demand for labor may result in higher nominal wage awards in these industries, which could then influence general

wage settlements vis-à-vis unit labor costs of production and consequently domestic prices throughout the economy[34].

### *2.3. Feedback From Prices To The Exchange Rate*

The cause-effect relationship between the exchange rate and prices is not one way. The circle is completed by the feedback from prices to the exchange rate. This raises an issue of "vicious circle hypothesis" which states that, in a world of floating exchange rates, an initial disturbance can set in motion a cumulative process of price inflation and exchange rate depreciation through which the exchange rate effect is rapidly passed through into domestic prices, which in turn feeds back upon the exchange rate[35].

In a market where exchange rates are allowed to fluctuate according to the forces of supply and demand, exchange rate movements are likely to reflect the changes in inflationary expectations. In the literature dealing with expectations, Dornbusch (1976) observed that, the spot exchange rate is almost entirely dominated by the course that the public expects it to take in the near future. If expectations about the rate of inflation are based on the view that price trend will continue into the future, the changes in prices may directly affect expectations about future rates of inflation. A study by Camarazza (1986) in particular has shown how price changes may put downward pressure on the current exchange rate if the public comes to believe that the monetary policy is not likely to be directed towards

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[34] For a detailed analysis on inflationary effect of exchange rate changes, see for example Caramazza (1986) The Interaction between Exchange Rate Changes and Inflation and De Brouwer, Ericsson and Flood (1994) Modeling and forecasting inflation in Australia.

[35] The reverse process in which an appreciating exchange rate lowers domestic prices and wages, thus leading to further appreciation of the exchange rate, has been termed the "virtuous circle." (Basevi and De Grauwe 1977)

restraining the higher rate of inflation induced by the depreciation. On his part, Carbaugh (1992) pointed out that individuals would adjust their portfolio of financial assets when they decide that home inflation is likely to increase in the near future. Under a flexible exchange rate regime, expectation of a future price increase at home will imply expected depreciation of the domestic currency[36]. To reduce possible loss due to expected fall in value of the domestic currency, exchange rate traders would reshuffle their portfolio of financial investments, thereby causing exchange rate changes.

Proponents of PPP theory also argue that the nominal exchange rates adjust over time to offset any divergent movements in relative national prices. According to PPP theory, a currency maintains its purchasing power parity if it depreciates by an amount equal to the excess of domestic inflation over foreign inflation. In its revised form, the causal effect from price changes to exchange rate in equation {2.1} can be stated as:

*{2.26}* $$\bar{e}_t = \bar{p}_t - \bar{p}_t^* + u_t$$

where $\bar{e}_t$ is the rate of currency depreciation, ( $\bar{p}_t - \bar{p}_t^*$ ) is the rate of excess inflation in the home country, and $u_t$ is the disturbance term. The time subscript is t. All variables are expressed in percentage changes. Expression *(2.26)* states that, if there is a rise in the price level in home country relative to that in foreign country, there will be a once-for-all corresponding depreciation of the home currency. On the other hand, Lee (1976) noted that

[36] This assertion is based on the notion of PPP theory

there would be a once-for-all rise in the price level in the home country if the home currency depreciates[37].

### *2.4. Summary*

Over the years, substantial body of theoretical work has addressed the issue of exchange rate pass-through (the transmission of exchange rate changes to import prices), either directly or as part of discussion of how exchange rate changes might affect the trade balance. In theoretical terms, the pass-through effect depends on the elasticity of export supply and import demand of the country and its trading partners. A small country, which can be assumed to face an infinity elastic supply of exports from its trading partners is likely to experience a complete pass-through on the import side whereas a partial pass-through can be expected with respect to the import price of a larger economy which faces an upward sloping supply curve.

However, strategic trade theory and the rise of market imperfections have led to a renewed interest in the pass-through analysis, which goes beyond the concept of elasticity. Theoretical explanations of pass-through now emphasize the role of market structure, followed by product characteristic to explain firms' pricing behavior. These models have been concerned with explaining whether the empirical data on pass-through merely reflects short-run squeezing of profit margins by exporters, or if a particular type of market organization always leads to only a limited response of prices to exchange rate changes.

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[37] For a more complete discussions on PPP theory, see Cassel (1918, 1923), Frenkel (1978), on the criticisms of PPP, see for example Balassa (1964), Officer (1976), Gibson (1996)

Under the condition of imperfect competition, producers would be in a position to charge a mark-up on costs to earn above normal profits even in the long run.

The variation in mark-ups over marginal cost resulting from an exchange rate change however, depends on the degree of substitutability between the domestic and imported goods, as determined by the degree of product differentiation and the degree of market integration or separation. The common feature of all the models reviewed is that, depreciation should lead to an increase in prices of imports. In the case of a perfectly competitive market with homogeneous goods, exporting firms will charge a price prevailing in the domestic market. If products are differentiated, it will be the case that the relative prices of the imported brands increase in response to depreciation. This suggests that at least two conditions need to be met for a complete exchange rate pass-through. It requires that mark-ups of price over marginal costs remain unchanged and that the marginal cost of production is constant.

The interesting revelation of this survey is that price responses differ across different destinations. This difference reinforces the notion of the failure of the law of one price for manufactured goods and also suggests an existence of incomplete pass-through and market imperfections in international trade. It is also revealed that firms are more likely to respond to large, permanent exchange rate changes than to changes that are small and temporary. If exchange rate change is large and permanent, a firm may respond by changing its export price, expanding or contracting production and distribution. In the case of small and temporary changes, its response may be to absorb changes in its product mark-up rather

than adjust price. Studies that took into consideration the hysteresis effect have shown that firms are less likely to enter a market following a temporary and small exchange rate change if there are significant sunk costs involved. 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 exist. This often results in a low rate of pass-through as firms fight to either stay in the market or deter entry.

The instability in foreign exchange rate markets since the inception of the floating era has induced multinational corporations to actively employ intra-firm pricing policies that prevent the full transmission of the exchange rate changes to import prices. In a spirit of unfavorable exchange rate shocks, multinational corporations resort to the use of internal exchange rates for intra-firm transactions. The use of internal exchange rates enables foreign affiliates to insulate their pricing decision from large exchange rate fluctuations. These exchange rates usually differ significantly from the external or true exchange rate for prolonged periods since they serve merely as a clearing mechanism for intra-firm trade. Evidence suggests that the use of intra-corporate exchange rates is widespread among multinational corporations and that, its use is designed primarily to guard against unfavorable price consequences of large exchange rates movements. The widespread use of these internal exchange rates thus weakens the link between exchange rate changes and import prices. The leverage available to multinational corporations in determine the timing of payment on contracts through flexible internal credit arrangements enhances the ability of their subsidiaries to price-to-market independently of the current exchange rates.

However, the volatile climate of floating exchange rates still poses a much more serious and pressing problem for them. This involves the response mechanism of multinational corporations 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 in order to remain competitive in export markets.

While most investigations of exchange rate pass-through focus on the transmissions of exchange rate changes to import prices, it is not only import price that matters but also the retail consumer price that enters directly into measured inflation. Movements in the exchange rate have an impact on the prices of imported goods and inputs and through these price changes, there can be either direct or indirect effects on retail selling prices. The consumer price response to changes in prices of imported inputs caused by movements in the exchange rate depends not only on the share of imported input in production but also on other factors such as demand conditions, market share strategy, the cost of adjusting prices, and perceptions as to the duration of the depreciation. It also depends on the competitive structure of the industries in the domestic economy that depend heavily on imported inputs. The issue of exchange rate causality feedback relationship was also noted in the literature. The general analytical framework concerning causality feedback relationship points to the phenomenon of so-called vicious and virtuous circle, in which exchange rate fluctuation causes changes in domestic prices, which in turn feed back upon the exchange rates.

## *CHAPTER 3*

## *REVIEW OF EMPIRICAL LITERATURE*

### *Overview*

Empirical studies of the relationship between exchange rates and goods prices have been abundant since the inception of the floating era in the 1970s. These studies seek to determine the degree and the speed of exchange rate pass-through. Specifically, they seek to determine whether pass-through relation is complete, (or the law of one price holds) or exporters resort to price discrimination between the domestic and foreign markets. Much of the work on pass-through analysis has concentrated on the experience of the large economies particularly that of the United States[38]. The experience of the smaller and more trade-dependent economies has received less attention. Moreover, the estimates of pass-through for these economies were obtained from studies that examine pass-through in a multi-country context. These studies have produced mixed results. Even results for the same country from different studies have often been contradictory, leaving most exchange rate observers with a puzzle.

This chapter will, of course, not resolve this puzzle. It rather provides a critical survey of the empirical literature on exchange rate pass-through relations. The chapter is organized in the following manner. Section one reviews the evidence of exchange rate pass-through. It begins by reviewing the literature on multi-country studies, followed by literature on

[38] In my own random search in various articles and journals, more than 35% of the pass-through estimates were for the US. The U.S., and Japan command more than 50% of the estimates.

country-specific studies[39]. Section two synthesizes the main features of pass-through studies since the advent of the floating era. The emphasis is placed on the data and the methodology employed in the estimation of pass-through effects. In doing so, I compare the results of various studies, emphasizing the degree and dynamics of the pass-through of exchange rate changes to price, the pattern of pass-through across countries and across products, and the stability of pass-through relationship. Finally, section three reviews literature on causality feedback relationship between exchange rates and prices.

### *3.1. Evidence of Exchange Rate Pass-Through*

If there are good theoretical reasons for believing that exchange rates and prices have causal effects and thus pass-through is inevitable, then it is not surprising that empirical studies have found evidence in its favor. As in any standard economic textbook, exchange rate pass-through is also the percentage change in local currency prices of import resulting from a percentage change in the exchange rate between the exporting and importing countries. Exchange rate pass-through is "full" or "complete" if there is one-for-one response of import prices to exchange rate changes. In chapter two, it was noted that at least two conditions are required for complete exchange rate pass-through: (i) it requires that markups of price over cost must be unchanged and (ii) marginal costs of production must remain constant. In a typical pass-through regression model such as one expressed in chapter two (for analytical purposes we reproduced it here as),

[39] While multi-country study allows easy comparison, country-specific study allows us to adequately examine the characteristics of each country as well as its policy implications.

$$\{3.1\} \qquad P_t = k + \beta E_t + rX_t + gR_T + \mu_t$$

where $P$ represents a local currency import price, $E$ is the exchange rate defined as importer's currency per unit of exporter's currency. The coefficient $\beta$ is referred to as the pass-through co-efficient. It lies between 0 and 1. Exchange rate pass-through is "full" or "complete" if $\beta = 1$ and is "incomplete" if $\beta < 1$.

Prior to the official change from fixed to flexible exchange rate regime in 1973, there was a transitional stage for a couple of years when some of the industrialized nations recognized the need for adjustment in the foreign exchange market[40]. One study that bridges the gap of transition from fixed to flexible exchange rate regime was by Kreinin (1977).

Kreinin examined the effects of exchange rate changes on the prices and the volume of foreign trade. He uses a "natural experiments" approach to estimating the degree of pass-through that occurred following the currency realignments of the transition period. Whereas the standard pass-through study uses regression analysis to control for other factors, Kreinin uses an import price from a second exporter whose exchange rate did not change relative to the importer. Traded goods prices were proxied by the consumer price index. His principal result is summarized below (Kreinin 1977 p.318).

[40] Canada was one of the first industrialized nations to float its foreign exchange operations in 1970 with respect to US dollar

*Table 3.1. Estimated pass-through effects for six industrial countries: 1970-1972*

| Country | Control Country | Commodity | Estimated Pass-through[41] (%) |
|---|---|---|---|
| Belgium | Austria, Switzerland | Imports | 90 |
| | Netherlands | Exports | 75 |
| Canada | Italy | Imports | 90 |
| | U.K. | Exports | 60 |
| Germany | Netherlands, Belgium | Imports | 60 |
| | Austria, Switzerland | Exports | 90 |
| Italy | France, Denmark | Imports | 100 |
| | Norway Sweden | Exports | 100 |
| Japan | Germany, Belgium | Imports | 80 |
| | Switzerland | Exports | 85 |
| U.S. | Canada, U.K | Imports | 50 |
| | Finland | Exports | 100 |

From these statistics, it is clear that pass-through effect is generally incomplete, and tends to vary inversely with the size of the country. Kreinin interprets incomplete pass-through as a reflection of either incomplete adjustment during the sample period or "largeness" of the importer in the sense of being able to influence the world price. However, he was surprised by the pass-through result for the United States but attributed it to change in the direction of causality between exchange rates and prices as a result of switch from fixed regime to flexible regime. He contended that under fixed exchange rates, changes in the exchange rate initiate changes in prices while under a flexible regime the direction of causality runs from prices to exchange rates. This assertion that under flexible exchange rates causation runs from prices to exchange rate seems to support the PPP (Cassel 1918) hypothesis where exchange rate changes reflect the price level differentials between two nations.

[41] A pass-through on the import side is defined as the percentage of the devaluation translated into an increase in domestic prices.

Spitaller (1980) investigated effects of exchange rate changes on terms of trade as well as trade balance. His motivation for the study stemmed from the persistence of large payments imbalances of the U.S. economy in the face of considerable swings in the exchange rates during the early period of the floating era. Spitaller's main concern was to address the magnitude and short run time path of the effects of exchange rate changes on imports for the U.S. and its major trading partners. He used import unit values as traded goods prices to estimate the response of prices to a 10 percent depreciation over the period 1973-78. The estimated results suggest complete pass-through for all countries except Germany, where about 73 percent of the change is passed through. However, the timing of the pass-through differs across countries. It takes up to seven months in Belgium for complete pass-through, four months in Canada, eleven months in France, three months in Italy, two months in Japan, twelve months in the Netherlands, six months in Sweden, and nine to ten months in the U.K. and the U.S.

A similar study by Khosla and Teranishi (1989) employed an ordinary least squares procedure for the first differences of the investigated variables. In this study, significant differences in the pass-through relation across countries were observed. Pass-through ranges from a high of 96 percent for Sweden to as low as zero for Norway. Surprisingly, the larger developed economies such as the U.S. and Japan recorded relatively high rates of pass-through, whereas the smaller less-developed economies such as the Philippines and Indonesia recorded relatively low rates. This result contrasted sharply with Kreinin's (1977) assertion that pass-through tends to vary inversely with the size of the country.

Gagnon *et al.* (1995) also estimate pass-through in a multi-country study using a panel data set of automobile exports from four source countries to twelve destination markets including Canada over the period 1970–88. Gagnon *et al.* find that pass-through is lowest when the source country's market share is around 40 percent and highest when market share approaches 100 percent.

Country-specific research of exchange rate-price relationship has been dominated by analysis of the pass-through to the United States. Such studies include Shwartz and Perez (1974), Magge (1974), Woo (1984), Mann (1986), Kreinin et al. (1987), Helkie and Hooper (1988), Baldwin (1988), Moffet (1989), Feiberg (1989), Kim (1990, 1991). Helkie and Hooper (1988) used the U.S. non-oil aggregate quarterly data from 1969 to 1984 to simulate traded good prices response to 10 percent depreciation. Pass-through on import of 91 percent was estimated, with lags extending up to eight quarters. Pass-through on exports ranged between 80 to 100 percent, with lags extending from up to four quarters. Klein and Murphy (1988) estimated average pass-through of 85 percent for the U.S. imports from Japan and Germany. Moffet (1989) gives pass-through of around 50 percent, with lags extending to eight quarters. He finds pass-through to be stable during the period of floating exchange rates. Marquez (1991) employed a maximum likelihood estimator for the U.S. exports to Canada, Germany, Japan, UK and other OECD countries. His estimated pass-through effect ranges from 23 percent for the UK to 110 percent for the block of other OECD countries over the period 1973-84. Recent studies by Gron and Swenson (1996) give slightly more than 50 percent for U.S. automobile imports from Japan over the period 1984-93.

Elsewhere, Menon (1993) employed quarterly data for motor vehicles imports to estimate the pass-through effect for Australia. He used true prices of imports with a foreign cost of production index as a weighted average of industry-specific labor and material costs for the five major import-supplying countries. Engle-Granger's (1987) two-step procedure was employed to estimate the model. Time-series properties of the data were tested using the Dickey-Fuller tests. Menon estimated pass-through of 80 percent in the long run and 70 percent in the short run. Dwyer and Lam's (1995) estimation for Australia gave 66 percent pass-through over the period 1971-93.

Clark (1991) estimated close to complete pass-through for Bostwana imports between 1976 and 1987, with lags extending to fifteen months. Athukorala (1991) found pass-through between 71 and 82 percent for Korea exports from 1980 to 1989 while Moreno (1989) estimated 58 percent for Korea and 38 percent for Taiwan in almost the same period (1974-87). In the UK, Cowling and Sugden (1989) estimated partial pass-through for both exports and imports from 1979 to 1980. Studies by Ohno (1990) estimated pass-through of Japanese exports to the U.S. from 1977 to 1987. He employed an iterative three-stage least squares estimator, with a constant and once-lagged dependent and independent variables as instruments. He also estimated pass-through of about 80 percent.

In Canada, an EconLit Database search turned up with few entries for articles that cover topics relating to exchange rate and import prices. These include Kreinin (1977), Spitaller (1980), Kawai (1984), Caramazza (1986), Schembri (1989), Kasa (1992), Gagnon *et al.* (1995) and Lefleche (1996). Most of these studies were conducted in a multi-country

context. Schembri (1989) estimated pass-through of Canadian exports to the U.S. from 1973 to 1985. This estimation was conducted in two stages, using iterative three–stage least squares and the seemingly unrelated regression technique. Schembri observed price discrimination between the domestic and the U.S. market, with larger markup on exports to the U.S. Kasa (1992) also employed seemingly unrelated regression technique to estimate pass-through for a variety of Canadian imports from Germany from 1978 to 1987. He also observed incomplete pass-through with significant variations from product to product.

### *3.2. Features of Pass-Through Studies*

Estimation of pass-through usually entailed more than estimating an equation of a particular model using ordinary least squares (OLS). Various tests such as test of causality, test for stability of the pass-through coefficient and even pass-through equation itself have been performed. Issues such as non-stationarity, simultaneity, dynamic adjustment, and symmetric response of price to costs, exchange rates and competing prices have also received some attention in the literature. Differences in methodology, model specification, and variable construction have been a hallmark of exchange rate pass-through analysis.

An examination of pass-through relations using time series data requires stationary series of exchange rates, import prices and other relevant variables. In many economic time series, departures from stationarity occur because of the lack of central tendency toward mean values. Most studies, however, achieved stationarity by successive changes or differences of the variables by finding a linear operator that transforms a given time series into a stationary process. This approach usually works when time series is assumed to be homogeneous non-stationary, that is, its behavior at different periods in time is essentially

the same. Another group of studies achieved stationarity by endogenously obtain a lag operator that transforms exchange rates, prices and others variables into stationary time series. Other groups of researchers employed different procedures to ensure stationarity of the investigated variables. For example, some researchers run a distributed lag regression equation proposed by Sims 1972 by including a time variable as one of the explanatory variables in the right-hand side of the equation with the hope that the time variable will remove the secular time trend existing in the variable and thus achieve stationarity.

The empirical evidence has shown that the selection of data for analyzing exchange rate pass-through can make all the difference in the entire analysis. The use of quarterly data was most common but with different sources and types. Some studies relied on consumer price index as a proxy for traded goods price (Kreinin 1977), other employed traded goods unit values as a proxy for import prices (Spitaller 1980; Khosla and Teranishi 1989; Moreno 1989). However, such proxies usually cast doubt on the estimated results as well as the entire analysis due to bias or error they may introduce into pass-through relations.

The measurement errors resulting from price proxies have received attention in a study by Alterman (1991)[42]. In that paper, Alterman compares the exchange rate pass-through results obtained using Bureau of Census unit values indices and BLS import price indices. Pass-through values on imports using import unit values were significantly lower than those obtained using import price index. For capital goods in particular, exchange rate

[42] Alterman, W. (1991) "Price Trends in U.S. Trade: New Data. New Insights." In P. Hooper and J. D. Richardson (eds) *International Economic Transactions: Issues in Measurement and Empirical Research*: 109-39

pass-through was 50 percent using import price index and 33 percent using import unit values. The difference between the two estimates raises doubt about the reliability of pass-through estimates obtained using price proxies.

It is not only the measurement of import prices that raises concern about the reliability of pass-through analysis, but also the measurement of the exchange rate itself. While some studies employ a currency-contract-weighted exchange rate index, others employ a proxy in the form of a traded-weighted exchange rate index. Such studies stress the importance of factors such as the number of currencies included and the weighting scheme employed to construct an index. These indexes are likely to under- or overstate exchange rate fluctuations and hence pass-through relations.

Most pass-through studies employed conventional ordinary least squares (OLS) to estimate exchange rate pass-through. A few have employed vector autoregression (VAR) models, while some authors use maximum likelihood estimator. Of the studies using OLS, some employ a serial correlation correction mechanism while others do not. In particular, Cochrane-Orcutt transformation was commonly used for the correction of serial correlation while the augmented Dickey-Fuller test was mostly used to test for time-series properties of a data. As already indicated, since in many economic analyses the problem of non-stationarity is common with time series data spurious regression becomes a major issue if OLS is used to estimate the data. This issue was heightened particularly when Menon (1995) reports that a significant number of previous studies report high $R^2$ and low Durbin-

Watson statistics. This may reflect non-stationary residuals and the likelihood of a spurious relationship becomes high.

The majority of the studies employ polynomial distributed lags to capture the dynamic response of traded goods prices to exchange rate, but impose different orders on the shape of the polynomials. Some studies entered the lags unconstrained while others imposed constraints and at different points. In determining the optimum orders of lags, a group of authors adopted the minimum final prediction error (FPE) criterion proposed by Akaike (1969, 1970). The minimum final prediction error of a predictor is simply the mean squared prediction error. Akaike's criterion suggests that one has to pick the regression equation that yields the minimum mean squared error or final prediction error. Others also adopted minimum standard error of the regression to determine optimum orders of lags.

Some researchers used a foreign cost and capacity utilization of production variable in the model (Mann and Hooper 1989), while others employ a world price variable, constructed as a weighted average of export unit values of the import-supplying countries (Murphy 1988, Meade 1991). The Chow test was mostly used to test for a structural break in the pass-through relationship (Klein and Murphy 1988; Moffet 1988; Ohno 1989) but Kim (1990) finds problems with the use of the Chow test. Kim (1990) argued that chow test procedure which requires the assumption that a possible break is known *a priori*, may not produce the required results. He therefore employed a more general framework in the form

of the varying parameter approach[43] to test the structural stability of the pass-through equation, which according to Menon (1993), appears much more suited to the task.

The findings of exchange rate pass-through studies in general have shown that incomplete pass-through is a common and pervasive phenomenon across a broad range of countries. Not only are exchange rate changes never fully reflected in prices in the majority of these studies, but the lags corresponding to the partial pass-through process are quite extensive. Few studies that do find full pass-through generally point to even longer lags in the transmission of exchange rate changes to prices. Helkie and Hooper (1988) find that lags associated with import price pass-through extend to eight quarters, while Clark (1990) and Athukorala (1991) report lags extending to five quarters.

Empirical evidence from the multi-country studies indicates significant differences in the rate of pass-through across countries. Khosla and Teranishi (1989) find that pass-through ranges from a high of 96 percent for Sweden to as low as zero for Norway. Kreinin (1977) also reported pass-through from a low of 50 percent for the U.S. to full pass-through for Italy. However, there are conflicting conclusions regarding the ability to generalize about the degree of pass-through based on the size and openness of the country. While Kreinin (1977) finds that pass-through tends to vary inversely with the country, Khosla and Teranishi (1989) report that pass-through is almost complete for the larger economies such as the U.S. but very low for the smaller economies such as Philippines.

[43] See Kim, Y (1990) "Exchange Rates and Import Prices in the U.S.: A Varying Parameter Estimation of Exchange Rate Pass-Through." *Journal of Business and Economics Statistics* 8(3): 305-15

Pass-through also varies substantially across different exporting and importing countries, suggesting a phenomenon termed pricing-to-market. Empirical 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 destination markets. These studies suggest that firms practice price discrimination across export markets by varying the degree of pass-through of exchange rate changes. For instance Schembre (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. Gagnon *et al.* (1995) observed that Swedish exporters pass-through about 30 percent more of an exchange rate change than the French exporters, while German and the U.S. exporters pass-through about 60 percent more than the French exporters.

Differences in destination markets were also observed with very low pass-through in markets such as the U.S. and very high pass-through in countries such as Israel[44]. This effect was clearly evident during the sharp depreciation of the U.S. dollar from 1985 to 1988 when Japanese manufacturers refused to allow increases in dollar-price of their exports to be reflected in U.S. import prices. The result was only a partial pass-through of the dollar depreciation into the U.S. import prices (Ohno 1989, Marston 1990, Khosla 1991).

There are also significant differences in estimates of pass-through reported in different studies for a given country. The differences in the pass-through estimates point to the

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[44] See Gagnon *et al.* (1995 p. 206)

importance of the choice of data, differences in methodology and model specifications. Research has also revealed that pass-through tends to vary quite significantly across industries or product categories. In his studies of US imports for cars, trucks and heavy motorcycles, Feenstra (1989) finds that pass-through varies across products and that, it ranges from about 63 percent for compact trucks to nearly 100 percent for heavy motorcycles. Kasa (1992) finds varying degrees of pass-through for the U.S and Canadian imports of cars, shoes, brass, suits, sew, beer and wine from Germany over the period 1978-87.

Exchange rate economists have questioned both the stability of the pass-through coefficient in the import price equation and the stability of the import price equation itself in pass-through analysis[45]. These studies seem to support structural breaks in both the import price equation and the pass-through effect. Piggot and Reinhart (1985) find a break around 1982 when they examined US import price response to exchange rate changes in the 1980s. Baldwin (1988) also finds breaks in 1980 and 1983, but only when he uses a certain proxy for foreign costs. The problem with these studies is that they do not isolate whether or not the source of the instability is the pass-through coefficient.

Mastropasqua and Vona (1988) however, tested for stability of each parameter in an equation that relates the U.S. import price to foreign prices and exchange rates. They also rejected the hypothesis that the pass-through coefficient for industrial country suppliers of

[45] They include Piggot and Reinhart (1985), Mastropasqua and Vona (1988), Baldwin (1988), Klein and Murphy (1988), Moffet (1988), Ohno (1989), Kim (1991), Yang (1991), Athukorala and Menon (1994).

exports to the United States is stable. Mann (1986), Marston (1989), and Moffet (1989) also examined the pass-through coefficient over various periods of the floating era. Their results suggest that pass-through has fallen. Most of the studies interpret the structural break as evidence of a hysteresis effect in import pricing.

However, studies including Lattimore (1988), Mann and Hooper (1989), and Athukorala and Menon (1994) find otherwise. They find that both the import price equation and the pass-through coefficient are stable. Melick (1989), using the error correction method also finds similar results, suggesting the importance of the choice of proxy for import prices and foreign costs. A number of studies have also tested for asymmetric response of pass-through relations during periods of rapid depreciation and appreciation of the exchange rate. Mann (1986), Krenin *et al.* (1987) and Marston (1990) find asymmetry whereas Moffet (1989), Athukorala (1991) find no such evidence.

### *3.3. Tests For Exchange Rates-Prices Causality*

Although the issue of exchange rate-prices causality has generated quite a significant amount of literature, the number of empirical studies is rather small. In addition, the existing few studies leaves much room for further studies. Among such empirical studies were Lee (1976), Brillembourg (1976), Kawai (1984), Adler and Lehmann (1985), Taylor (1988), Patel (1990) and MacDonald (1993).

Lee's (1976) studies show the relationship between exchange rate movements and relative price changes using PPP theory. In that paper, Lee argued that there is a strong empirical relationship between changes in exchange rates and the difference in the changes in prices

levels in the United States and other major industrialized countries. Based on his empirical results a change in the exchange rate has a price level effect and vice versa. The empirical relationship between these variables was distinct over the short run as well as over the long run. Even though some differences in test results exist between general wholesale price index and consumer price index, his empirical relationship shows up well with both indices.

A Similar study by Basevi and De Grauwe (1977) shows that unanticipated exchange rate fluctuation causes changes in costs, wages and general prices that in turn induce further exchange rate changes. This analysis points to the phenomenon of so-called vicious and virtuous circles, in which exchange rate depreciation feeds back on domestic inflation which in turn feeds back upon the exchange rate. Kawai (1984) attempted to capture the direction of causality between unanticipated fluctuations in exchange rates and unanticipated movements in relative prices. Both consumer price index (CPI) and wholesale price index (WPI) were used as relative prices for ten industrialized nations over the period 1975-78. Kawai concludes that causation from changes in exchange rates to changes in the WPIs was observed almost as many times as the opposite direction, whereas changes in exchange rates tend to cause changes in the CPIs rather than vice versa. On the general view that exchange rate changes are the source of price instabilities, Kawai found support for this view for more than a half of the ten countries that he studied but it is quite difficult to draw general conclusions for those pegged countries that are concerned with the impacts of exchange rate depreciation upon domestic prices suggesting the need for more country-specific analysis.

Patel (1990) employed a cointegration method to test for a relationship between exchange rate fluctuations and the extent to which they reflect inflation differentials between two countries using Engle-Granger two-step technique. He used an equation similar to expression {2.26} in chapter two. A similar test was also conducted by MacDonald (1993) using monthly data from January 1974 to June 1990 for the U.S. dollar vis-à-vis the British sterling, French franc, Deutshmark, Canadian dollar and the Japanese yen. Both studies found some evidence in support for the claim that exchange rates respond to relative prices changes. However, writing under the heading "purchasing power parity tests of causality and equilibrium," Brillembourg concluded that there does not seem to be any causal relationship between the exchange rate and relative prices. Similarly, Kugler and Lenz (1983), Adler and Lehmann (1985), Taylor (1988) using regression analysis find little support for exchange rates-prices causality.

### *3.4. Summary*

Empirical work on exchange rate-price relationship in general has produced mixed and interesting results. First and foremost, much of the studies have concentrated on the experience of the United States (accounting for almost one-third of the available pass-through studies). The research on other economies not only has received less attention but also most were conducted in a multi-country study context.

Pass-through analyses have entailed more than estimating an equation of a particular model using ordinary least squares. Issues such as non-stationarity, dynamic adjustment and symmetric response of price to exchange rates, costs as well as competing domestic prices

have received some attention. Various tests including tests of stability of the pass-through coefficient and tests for causality have also been performed.

Findings of exchange rate pass-through studies in general have shown that partial pass-through is common across a broad range of countries. Besides, these studies point to longer lags in the transmission of exchange rate changes to prices. However, significant differences have been observed in the pass-through results both in multi-country and country-specific contexts making it difficult to generalize the degree of pass-through based on the size and openness of a country. Pass-through also varies substantially across product categories.

Various results on the stability of the pass-through coefficient as evidence shows are difficult to compare because of the different estimation techniques and the choice of test statistics. While some authors examine the whole equation, others limit their analysis to certain variables in the equation. On balance, the literature seems to support structural breaks in both the import price equation and the pass-through coefficient. Estimates of causality feedback relationship have also produced different and varying results thereby making generalization quite a difficult task for those economies that are concerned with the impact of currency depreciation on aggregate price levels. Even estimates for the same country from different studies have produced mixed results suggesting the importance of the choice of data, methodology and model specification in the exchange rate-price relationship.

# *CHAPTER 4*
# *EMPIRICAL METHODOLOGY*

Every analysis of an economic process is based on some underlying logical structure known as model that describes the behavior of the agents in the system. This process begins with the specification of the model to be estimated, the variables to be included and the functional form connecting these variables. This chapter examines the conceptual framework underlying the exchange rate-prices relationship. The chapter is organized as follows: Section 4.1 presents the theoretical model for estimating exchange rate pass-through. The section also derives equations to investigate causality in a bivariate framework within which I will test whether fluctuations in exchange rate help to explain fluctuations in prices as well as the reverse relationship. Section 4.2 outlines the estimation procedures for cointegration regression and error correction mechanism.

## *4.1. Analytical Framework*

### *4.1.1. The Pass-Through Models*

Given the long and varied history of exchange rate pass-through it is not surprising that a number of economists have studied this subject and have specified models for its explanation. Most theoretical explanations begin with the assumption of the law of one price (Mann 1986, Hooper and Mann 1989, Dwyer and Lam 1995). In essence, we can think of the exchange rate pass-through as an application of the law of one price. Under the conditions of perfect competition in the domestic and international commodity markets where firms enjoy only normal profit, the exchange rate equates the domestic currency

prices of similar traded goods produced at home and abroad such that a ratio of domestic import price to exchange rate equals foreign price:

$$\frac{P^m}{E} = P^{m^*} \qquad \{4.1\}$$

where $P^m$ is price of imports in domestic currency, $P^m*$ is its corresponding price in foreign currency and E is the exchange rate. The significance of expression (4.1) can be seen by considering the elasticity of the import prices with respect to exchange rate defined as domestic currency per unit of foreign currency. If the foreign price remains unchanged, elasticity of the import price in domestic currency with respect to the exchange rate can be defined as:

$$\frac{d \ln P^m}{d \ln E} = 1 \qquad \{4.2\}$$

where *ln* denotes natural log. Thus, if domestic economy is the price taker in the foreign market then all of a change in the exchange rate can be passed on to a change in the domestic currency price of imports and the pass-through is expected to be complete. However, if the domestic economy is not a price taker in the foreign market, then foreign firms may have to adjust the foreign currency price of the imports following an exchange rate adjustment. In this case the exchange rate pass-through may be less than complete.

In dealing with pass-through relations, it matters a great deal for thinking about the exchange rates and the commodity prices whether the market is integrated or segmented. The integrated market is one where geographic factors or nationalities do not have systematic effects on goods prices. Perfect competitive markets usually assumed to be integrated. However, market that is integrated may or may not be perfectly competitive. For instance, a monopoly supplier of a commodity may charge a price above the marginal costs but be incapable of price discrimination if buyers are well organized or the product is easily transported across markets. On the other hand product market may be segmented if the location of the buyers and sellers influences the terms of the transaction. A segmented market implies the existence of market power because not all buyers face a price equal to marginal costs.

In industrialized economies as in Canada, most markets for manufactured imports are imperfect and segmented for a variety of reasons. Factors leading to imperfect competition include imperfect substitutability of products so that each supplier has some level of market power; production technology may not exhibit constant return to scale so that the supply curve may be upward sloping, and a relatively small number of firms in a particular industry[46]. In addition, manufactured goods purchased in a foreign market may be assessed additional taxes at the border and may not comply with the regulations in the home market. Besides, warranties, and service are often linked to the location of purchases. By making resale across nations costly, these factors may permit nearly identical goods to sell for different prices in two different markets without inducing profitable third-party arbitrage.

[46]For more detailed discussion on the factors leading to market imperfections, see for example Isard, P. (1977).

These factors suggest that both the supply and demand curves for manufactured imports may not necessarily be infinitely elastic, suggesting the importance of profit margin or the "mark-ups adjustments" in the exchange rate pass-through relations. The mark-ups in the relationship between the exchange rate and the prices permit an extension to the pass-through analysis beyond the conventional law of one price. The mark-ups in pass-through relations also allow more flexibility in the analysis of exchange rate impact on import prices.

A foreign firm usually sets a price in its own currency at a mark-up over its unit cost of production. The identity that relate foreign price, costs of production *(C)* and mark-ups *(K),* all in foreign currency can be written in some functional form as:

*{4.3}* $$P^{m*} = K^{*}C^{*}$$

{4.4} $$d \ln P^{m*}/dt = d \ln K^{*}/dt + d \ln C^{*}/dt$$

Equation {4.4} means that the change of foreign currency price of imported products equals the change in foreign cost of producing the product plus the changes in the mark-ups. If we substitute equation *{4.3}* into expression *{4.1}* we have;

*{4.5}* $$P^{m} = K^{*}EC^{*}$$

Taking natural logs of expression {4.5} and differentiating over time , we can write,

*{4.6}* $$d \ln P^m / dt = d \ln C^* / dt + d \ln K^* / dt + d \ln E / dt$$

Thus, a change in the domestic price of imports equals a change in foreign costs plus a change in exporters' profit margins measured by the mark-ups plus a change in the exchange rate. The identity in equation *{4.6}* suggests that if foreign costs remain constant and mark-ups also remain unchanged, the exchange rate pass-through will be complete. Conversely, pass-through will be less than complete if the mark-up or profit margin adjusts to offset some of the exchange rate changes. The concept of pass-through simplified in equation *{4.6}* is a modified form of the law of one price where mark-up is assumed to be constant. But evidence has shown that the mark-up over costs is not always constant. Firm's mark-up may well vary in part because of the characteristics of market structure in the individual industries and in part because of the overall changes in the macroeconomic environment

The mark-up model, in the version put forward by Hooper and Mann (1989) assumed that foreign supplier sells in several different markets and has some degree of control over the prices in the foreign market because of the product differentiation or other market imperfections. The model also assumed that the mark-up is a variable and responds to both competitive pressures in the domestic market and demand pressures in all market combined. Under these assumptions, the competitive pressures in the domestic market are measured by the gap between the competitor's price in the domestic market and foreign

production costs in domestic currency, while the demand pressures on foreign output is measured by the capacity utilization. The expression for mark-up *(K)* as stated in Hooper and Mann (1989 p.300) can be re-written as:

*{4.7}*
$$K^* = \left[\frac{P^c}{EC^*}\right]^{\lambda} (C^{u^*})^{\delta}$$

Where $P^c$ = Competing price (domestic)

$C^*$ = foreign cost of production in foreign currency

E = exchange rate

$C^{u*}$ = Capacity utilization

and $0 \leq \lambda \leq 1, \quad 0 \leq \delta < 1$

Substituting $K$ in expression *{4.7}* into *{4.5}*, we have,

*{4.8}*
$$P^m = (P^c / EC^*)^{\lambda} \times C^{u^{*\delta}} \times EC^*$$

The usefulness of expression {4.8) is enhanced by considering the logarithmic differential denoting percentage change of respective variables as;

*{4.9}*
$$p^m = (1-\lambda)[e + c^*] + \lambda p^c + \delta c^{u^*}$$

where small letter case represents the natural log of respective upper letter case. The partial derivative of import price ($p^m$) with respect to exchange rate ($e$) is $(1-\lambda)$ which is the exchange rate pass-through coefficient and $\lambda$ is expected to take values from zero to one. At the extreme end where foreign firm is price taker in the competitive domestic market so that $\lambda$ is equal to one, pass-through is zero. This means that at a given level of $c^{u*}$ the foreign exporter will set a destination import price equal to prevailing domestic price and exchange rate or foreign costs have no effect. Thus, the markup absorbs the shocks to the exchange rate or the foreign costs. At the opposite end where foreign firm does not face any competition in the domestic market such that $\lambda$ is equal to zero, the markup remains constant and pass-through is complete.

Alternative equation expresses exporter's profit margin as a function of the gap between domestic competing price and foreign cost in domestic currency and the capacity utilization as:

$$p^m - e - c^* = \lambda(p^c - e - c^*) + \delta c^{u*} \qquad \{4.10\}$$

Expression (4.10) indicates that a rise in exchange rate, that is, depreciation of the destination currency may result in a decline in the exporter's profit margin when $\lambda$ is close to one.

Relationships of exchange rates and prices and firm's reactions to changes in them are not static. They may well change over time. For instance a firm may be willing to squeeze

profit margin to maintain market share temporarily in response to a decline in the value of exchange rate, but over time profit may return gradually to a desired level. To introduce dynamics into the model we express pass-through coefficients as a distributed lag model as:

$$\{4.11\} \qquad P^m = \sum_{i=0}^{T} [\{1-\lambda_i\}(e+c^*)_{t-i}] + \lambda p_t^c + \delta c^u \,;$$

In this case, the short run pass-through coefficient or instantaneous effect of the exchange rate changes on the import price would be $(1-\lambda_0)$ and long run pass-through effect would be $\sum (1-\sum_{i=0}^{T} \lambda_i)$. In a situation where pass-through increase gradually over time, and eventually becomes complete, the initial coefficient $\lambda$ would be close to one and subsequent values of $\lambda$ would be smaller and smaller and even negative so the $\sum_{i=0}^{T} \lambda_i$ would approach zero over time. Thus, the mark-ups may respond immediately to a change in the exchange rate but over time would return to their original levels.

The model as expressed in equation *(4.11)* imposes the same restrictions of pass-through on exchange rates and foreign costs but exchange rates tend to be much more volatile over time than production costs. Firms may be more willing to absorb a change in exchange rates into their profit margins, particularly when they are likely to expect currency appreciation in near future than to absorb changes in costs, which are more likely to be sustained. At least firms react differently to shocks induced by the exchange rate changes than to shocks to costs. To appropriately capture different effects on import prices due to

changes in exchange rates and/or costs, we allow the coefficient of each variable to differ in the model. For this reason we re-write equation *(4.11)* with different coefficients for exchange rate and costs. (whether or not the coefficients of exchange rate and costs are the same need to be tested). The unrestricted equation becomes:

$$\{4.12\} \qquad p^m = \mu + \sum_{i=0}^{T} \beta_{ii} e_{t-i} + \sum_{i=0}^{T} \eta c_t^* + \lambda p_t^c + \delta c^{u*}_t + \varepsilon_t$$

where $\beta = 1 - \lambda$; $\mu$ is constant and $\varepsilon$ is the error term. The short run pass-through coefficient is now $\beta_0$; $\beta_0 = 1 - \lambda_0$ and long run pass-through coefficient $\sum_i^T \beta_i$; $\beta_i = 1 - \sum_i^T \lambda_i$. The theoretical underpinnings of this model were first introduced in a study by Mann (1986). Hooper and Mann (1989) extended it in several ways when they examined the exchange rate pass-through for the U.S. economy in the 1980s. The model provides an intuitively appealing and attractive version of why we observe partial exchange rate pass-through and has attracted several other authors to use it to explore similar areas of interest. Hooper-Mann estimations for the U.S. economy are summarized below:

***Table 4.1: Estimated coefficient for U.S. economy, 1980-1988***

| | Coefficients<br>*Long-run* | t-ratio |
|---|---|---|
| $\frac{\partial p^m}{\partial e}$ | 0.58 | 4.97 |
| $\frac{\partial p^m}{\partial c^*}$ | 0.51 | 12.96 |
| R-square = 0.9982 | Standard error = 0.0067 | |

Source: Hooper and Mann (1989)

The results suggest a substantially less than full pass-through. The short run coefficient indicates about 20 percent pass-through for total manufactured imports while long run effect on import prices of changes in the exchange rate hovered around 58 percent with lags extending from 5 to 7 quarters. Pass-through for manufactured imports from Japan as quite similar, ranging between 50 and 56 percent with lags extending from 5 to 7 quarters. The long run pass-through of changes in the exchange rate and foreign costs are relatively equal.

Athukorala (1991) adopted Hooper-Mann model and has estimated equation *{4.12}* for Korea exports. Pass-through between 71 and 82 percent were estimated with lags extending from 4 to 5 quarters. Khosla (1991) also adopted Hooper-Mann model to estimate pass-through effect of Japanese exports. Average pass-through of 43 percent was reported with significant differences in the rates across industries. Studies by Melick

(1989) also estimated equation similar to equation (4.12) with aggregate data using error correction techniques. For Canadian imports of manufactured products from the U.S., equation (4.12) will be estimated for the period 1977–2000 using error correction techniques.

### *4.1.2. Causality and Feedback Relations*

Since Granger's (1969) seminal paper, the nature of causality and how to test for its existence has received some attention in economics. Economists have employed various techniques to analyze the causal relationship between two economic variables based on Granger's concept. For example, Sims (1972) employed Granger's concept to develop a unique procedure of causality testing. He run a regression of one "prewhitened" variable on current, past and future values of another "prewhitened" variable as a two-sided distributed lag model, and tested whether or not the coefficients of these values are significant as a whole. Pierce and Haugh (1977) have also suggested a "cross-correlated" between the "prewhitened" variables, and examine whether or not the simple autocorrelation functions are significantly different from zero as a whole". On his part, Hsiao (1978b) employed an alternative approach to causality detection. He regressed a stationary variable, say A, on its own past values and on current and past values of another stationary variable, say B, and tests whether or not the existence of B in the regression equation would improve the prediction of A. Causality, defined in the sense of Granger's (1969) concept has been applied to many economic issues such as money-income causality (Williams, Goodhart and Gowland 1976, Holmes and Hutton 1992), wage-price linkage (Mehra 1977), government expenditure-national income causality (Holmes and Hutton

1992) and money-price causal relationship (Frenkel 1977). All these studies have produced different and varied results for different countries.

This section continues in this empirical tradition by deriving functional equations to detect the direction of exchange rate-price causality in Canada under the present system of floating exchange rates. The concept of "causality" and "feedback" in the sense of Granger can be defined formally in the following manner: Let A and B be stationary stochastic processes, $\overline{A}$ and $\overline{B}$ be sets of past values of A and B respectively *{i.e.* $A_{t-j}, j = 1, 2, \ldots, \infty$; $B_{t-j}, j = 1, 2, \ldots, \infty$*}*. Let $\sigma^2(A/U)$ be the variance of the error series of the optimum, unbiased, least square predictor of A using the set of information on U that may contain A and B and their past values. "Causality" and "feedback" defined by Granger (1969) in a two-variable framework can be summarized as follows:

*Definition 1 (Causality)*: Given that $\sigma^2(B/\overline{B})$ represents the minimum predictive error variance of B using only past values of B and $\sigma^2(B/\overline{A}\overline{B})$ represents minimum variance if both past values $\overline{B}$ and $\overline{A}$ are used to predict B, then A is defined to cause B if $\sigma^2(B/\overline{A}\overline{B}) < \sigma^2(B/\overline{B})$. Thus, if we are better able to predict B by using the past values $\overline{A}$ and $\overline{B}$ than by using the past value $\overline{B}$ then we say that A is causing B, denoted by $A \Rightarrow B$.

*Definition 2 (Feedback):* if $\sigma^2(B/\overline{A}\overline{B}) < \sigma^2(B/\overline{B})$ and $\sigma^2(A/\overline{A}\overline{B}) < \sigma^2(A/\overline{A})$ then feedback is said to occur, denoted by $A \Leftrightarrow B$. Thus, feedback is defined to occur when A is causing B and in turn B causes A.

Causality-feedback relationship between two or more variables requires stationary series of the variables. For the purpose of detecting causality between exchange rates and prices level, we define variables $e_t$ and $p_t$ as the natural logarithms of the effective or traded-weighted indexes for spot exchange rates and consumer prices respectively. The Granger causality test assumes that the information relevant to the prediction of the respective variables, *e* and *p*, is contained solely in the time series data on these variables. In this sense the simple vector autoregressive model is given as follows:

$$\{4.13\} \qquad p_t = c_1 + \sum_{j=1}^{m} a_{1j} p_{t-j} + \sum_{j=1}^{n} a_{2j} e_{t-j} + u_t$$

$$\{4.14\} \qquad e_t = c_2 + \sum_{j-1}^{m} a_{3j} e_{t-j} + \sum_{j-1}^{n} a_{4j} p_{t-j} + v_t$$

where $c_1$ and $c_2$ are constants, $u_t$ and $v_t$ are white-noise, i.e $E[u_t u_s] = E[v_t v_s]=0$; $s \neq t$ and *m* and *n* are number of lags to be specified, *p* and *e* are consumer prices and exchange rate respectively. Equation {4.13} postulated that current prices are related to past values of prices itself as well as past values of exchange rates and equation {4.14} postulates a similar behavior for the exchange rates. Given the above specifications, we can distinguish the following cases:

- Unidirectional causality from *e* to *p* occurs if the estimated coefficients on the lagged values of *e*, in equation {4.13} are statistically different from zero as a

group (i.e. $\sum a_2 \neq 0$) and the set of estimated coefficients on the lagged values of $p$ in {4.13} is not statistically different from zero (i.e. $\sum a_1 = 0$).

- Unidirectional causality from $p$ to $e$ occurs if the estimated coefficients on the lagged values of $p$ in equation {4.14} are statistically different from zero as a group (i.e. $\sum a_4 \neq 0$) and the set of estimated coefficients on the lagged values of $e$ in equation {4.14} is not statistically different from zero (i.e. $\sum a_3 = 0$).
- Feedback or bilateral causality occurs if the sets of $e$ and $p$ coefficients are statistically significantly different from zero in both regressions. This implies that prices are better predicted by including past values of exchange rates and exchange rates are better predicted by including past values of prices and that a feedback relationship exists if both of these events occur.
- Independence or absence of causality will be suggested if the sets of exchange rates and prices parameters are not statistically significant different from zero in both regressions.

In general, since the future cannot predict the past, if exchange rate causes prices to change then changes in exchange rates should precede changes in prices. Therefore in a regression of prices on other variables including its own past variables, if we include past values of exchange rate and it significantly improves the predictions of price behavior, then we can say that exchange rate changes influence prices behavior. Similarly, in a regression of exchange rates on other variables including its own past variables, if we include past

values of price and it significantly improves the prediction of exchange rate movement then we conclude that price causes exchange rate to move.

### *4.2. Estimating Time Series Models*

Econometric analysis almost always begins with the use of the method of ordinary least squares (OLS). Under certain assumptions, the method of least squares has attractive statistical properties that have made it one of the most powerful and popular methods of regression analysis[47]. Following the implications of the well defined properties of the ordinary least squares, the initial pass-through model in equation {4.12} and causality feedback relations in equations {4.13} and {4.14} will be estimated using OLS techniques. In judging the acceptability of a time series model, the R-square, t-ratio, *F*-statistic and the signs of the estimated regression coefficients are important and it is essential that we have some prior notion of what to expect, at least for the key variables. Inevitably, there is always uncertainty regarding the appropriateness of the initial model specification vis-à-vis the assumption(s) of the OLS. With time series analysis in particular, the question of serial correlation, nonstationary series and the dynamic structure of the relationship between the variables also arises.

Since there is no unique way of characterizing the relationship in time series analysis between the dependent variable and the explanatory variables, one often formulates alternative models and then puts them through a number of diagnostic tests. To reveal potential econometric problems associated with time series analysis in this thesis, the

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[47] Assumptions underlying OLS are well discussed in Gujarati (1995) Chapters 10, 11 and 12.

estimated models will be subjected to the following three main tests: serial correlation, unit root and cointegration tests.

### *4.2.1. Serial Correlation in Time Series*

In the regression analysis, the OLS technique assumes that serial correlation does not exist in the disturbance term. It is there imperative that before using an estimated equation in time series analysis for statistical inference one has to examine the residuals for evidence of serial correlation. Durbin-Watson (DW) statistic is a natural first step in serial correlation detection and is usually reported as part of the regression output in any standard statistical software[48]. However, three main problems limit its usefulness as an adequate test for serial correlation. First, the distribution of the DW statistic under the null hypothesis depends on the data matrix of the independent variables. The usual approach to handling this problem is to place bounds on the critical region, creating a region where the test results are inconclusive. Second, if there are lagged dependent variables on the right-hand side of the regression, the DW test is no longer valid. Lastly, one may only test the null hypothesis of no serial correlation against the alternative hypothesis of first-order serial correlation.

Breusch-Godfrey (BG) LaGrange multiplier test overcome these limitations, and is preferred in most time series analysis. BG test of $p^{th}$-order autoregressive scheme is a

[48]The Durbin-Watson statistic is a test for first-order serial correlation. DW statistic measures the linear association between adjacent residuals from a regression model. If there is no serial correlation, Durbin-Watson (DW) statistic will be around 2. The DW statistic will fall below 2 if there is positive serial correlation (in the worst case, it will be near zero). If there is negative correlation, the statistic will lie somewhere between 2 and 4.

higher order autocorrelation test under the null hypothesis that *Ho:* $p_1 = p_2 = p_3 \ldots p_p = 0$; all autoregressive coefficients are simultaneously equal to zero. That is, there is no autocorrelation of any order. In the event that these tests reveal serious serial correlation problems, the economic model is re-estimated using a technique known as $p^{th}$-order autoregressive process or AR process. AR process is a technique, which assumes that autocorrelated residuals are the results of an autoregressive error process. The most widely used technique of estimating AR models is the Cochrane-Orcutt iterative procedure which is a multi-step approach designed so that estimation can be performed using standard linear regression[49]. Regression software packages such as Eviews3 estimates AR models using nonlinear regression techniques [50].

### *4.2.2. Stationarity, Unit Root in Time Series*

Regression analysis based on one time series variable on another time series variable, a very high R-square may not be meaningful if the time series involved exhibit strong stochastic trend. This situation signifies the problem of spurious regression if the high R-square observed is due to the presence of trend but not the true degree of association between the variables. Time series data is said to be stationary if the mean and the variance of the series are constant over time and the value of the covariance of the series do not depend on time. Any series that exhibit stochastic trend so that its mean is changing over time is said to be nonstationary. Nonstationary is assumed to be the result of a stochastic trend and removal of this trend would render the process stationary.

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[49] Prais-Winsten transformation, Hatanaka, and Hildreth-Lu procedures have also been used in the literature. However, Green (1997), Davidson and MacKinnon (1993), have argued that these approaches suffer from important drawbacks, which occur when working with models containing lagged dependent variables as regressors, or models using higher-order AR specifications.

[50] This approach has the advantage of easily extended to nonlinear specifications and models that contain endogenous right-hand side variables.

In economic analysis involving time series data the assumption underlying OLS estimation is that time series data are stationary series. If time series data are not stationary, the conventional hypothesis procedures based on student-*t*, *F*, chi-square tests and other statistical inferences arising from regression containing nonstationary variables may be misleading. To avoid the problems of nonstationarity and related spurious regression, time series analysis now incorporate *unit root* techniques to determine the presence of nonstationarity by examining the data generating processes for each variable. In many cases, simple differencing or some other transformation can achieve stationarity. A time series data is integrated of order *d* denoted by *I(d)* if it becomes stationary after being first differenced *d* times.

There are a number of tests that have been developed to test for unit root of economic variables. Dickey and Fuller (1979) tests take the unit root as the null hypothesis i.e $H_0$ equals one. If the absolute value of test statistic coefficient is greater than one, the series is explosive. Since explosive series do not make much economic sense, the null hypothesis is tested against the one-sided alternative that $H_1$: less than one. In the event of not rejecting the null hypothesis, the possibility is that the data series is integrated of a higher order or perhaps it is not integrated at all. To explore the possibility that the data series is integrated, one has to take the first difference of the first difference and test whether the unit roots exist. If the null hypothesis is rejected, the differenced series ($\Delta y$) is *I(0)* or original level form y is *I(1)*[51].

[51] Green (1997) has observed that series that *I(3)* or greater are extremely unusual, but they do exist.

The problem with Dickey-Fuller unit root test is that it valid only if the series is an *AR (1)* process. It does not address the potential problems associated with serial correlation with higher order. If the series are correlated at higher order lags, the assumption of white noise disturbances is violated and OLS is no longer BLUE. In an attempt to deal with this problem Dickey and Fuller (1981) use different methods to control for higher-order serial correlation in the series. The resultant test known as the Augmented Dickey-Fuller (ADF) test makes a parametric correction for higher-order correlation by assuming that the data series follows an *AR (p)* process by adjusting the test methodology. The ADF approach controls for higher-order correlation by adding lagged difference terms of the dependent variable to the right-hand side of the regression as a proxy of autocorrelation and time variable $t$ to capture the trend in the series. An important result obtained by Dickey and Fuller is that the asymptotic distribution of the test statistic is independent of the number of lagged first differences included in the ADF regression. While the parametric assumption that the data series follows an autoregressive (AR) process may seem restrictive, Said and Dickey (1984) demonstrate that the ADF test remains valid even when the series has a moving average (MA) component, provided that enough lagged difference terms are augmented to the regression.

An alternative test proposed by Phillips and Perron (1988) uses nonparametric method to controlling for higher-order serial correlation in a series. While the ADF test corrects for higher order serial correlation by adding lagged differenced terms on the right-hand side, the PP test makes a correction to the test statistic of the coefficient from the AR(p) regression to account for the serial correlation in error term. The correction is

nonparametric since it uses an estimate of the spectrum of error term at frequency zero that is robust to heteroskedasticity and autocorrelation of unknown form. The asymptotic distribution of the PP test statistic is the same as the ADF test statistic.

Perman (1991) compared the ADF parametric and PP non-parametric tests and has observed the relevance of each test. Perman argued that where uncertainty exists regarding the dynamic structure of the time series in question and where the random component may be non-white noise in quite general ways, the PP tests could be superior. That is, the power of ADF tests is likely to be low for series where moving-average terms are present or where the disturbances are heterogeneously distributed while the non-parametric adjustments are likely to raise the power of the tests in these circumstances.

### *4.2.3. Cointegration and Error Correction Mechanism*

Empirical studies in macroeconomics almost always involved nonstationary and trending variables. Conventional wisdom suggests that the appropriate way to manipulate time series data is to use differencing to reduce them to stationarity and then analyze the resulting series. Time series econometricians have questioned this accumulated wisdom. The main argument is that most economic theory is stated as a long-term relationship between macroeconomic variables in the level form and not their differenced form. Thus, analyzing time series data in their differenced form may result in a loss of valuable long-term relationship between economic variables.

Interestingly, recent research and a growing literature have shown that there are more logical and appropriate ways of analyze trending variables. If the two series are both

integrated of the same order I(d), then there may be a situation where linear combination of the two integrated variables results in an integrated of order zero *I(0)* or the partial difference between two series may be stable around a fixed mean. The implication is that the series are drifting together at roughly the same rate or they are on the same wavelength. Any combination of time series data that satisfy this requirement is said to be *cointegrated.* The resulting regression is known as cointegrating regression and the parameter estimates are cointegrating parameters[52]. A number of methods for testing for cointegration have been proposed in the literature. Augmented Engle-Granger (AEG) test proposed by Engle and Granger (1987) is based on assessing whether single-equation estimates of the equilibrium errors appear to be stationary[53]. A natural first step in the analysis of cointegration regression is to establish that the time series data are integrated of the same order and also ensure that cointegration is indeed a characteristic of the data. If the evidence suggests that the variables are integrated to different orders or not at all, then the specification of the model should be reconsidered.

One valuable contribution of concept of cointegration is to offer solution to problem of nonstationary variables. However, it is of limited use in analyzing the dynamic interaction between economic variables in the short-run. It offers no explanation as to how economic variables return to equilibrium for any given shock to the series. By modeling a technique that accounts for this limitation, Engle and Granger (1987) argued that if two or more data series are both integrated of the same order and cointegrated, there exist an error correction

[52]Granger (1986) "Developments in the Study of Co-integrated Economic Variables" *Oxford Bulletin of Economics and Statistics* 48

[53] The test proposed by Johansen (1988) and Stock and Watson (1988) is based on vector autoregressive (VAR) approach. For detailed discussion of the Johansen method, see Johansen and Juseliu (1990). A quicker method of finding out whether time series data is cointegrated or not, is Cointegrating Regression Durbin-Watson (CRDW) test based on Durbin-Watson *d* statistic obtained from the cointegrating regression. CRWD test is based on null hypothesis that Durbin-Watson statistic d=0 rather than the standard d=2

representation of the variables that corrects short-term disturbances. The error correction model (also known as Granger representation theorem) can be specified in the form:

$$\{4.15\} \qquad \Delta y_t = \beta_1 + \beta_2 \Delta x_t + \beta_3 v_{t-1} + \varepsilon_t$$

where $\Delta$ denotes first differenced of $d$ times, $v_{t-1}$ is the one-period lagged value of the residual from the cointegrating regression and $\varepsilon$ is disturbance with the usual properties. Equation (4.15) relates the change in $y$ to the change in $x$ and the equilibrating error *(v)* in the previous period. The parameter $\beta_2$ captures the short-run disturbances in $x$ whereas the coefficient of error correction term $\beta_3$ captures the short run adjustments toward the long-run equilibrium. The equilibrating coefficient $\beta_3$ indicates what proportion of the disequilibria in $y$ in present period is corrected in the next period.

### *4.3. Summary*

The formulation of a satisfactory econometric model is crucial to any conclusion drawn from it. An empirical research is usually an interactive process. This process begins with the specification of the model to be estimated. Specifying a model in turn involves several choices including the economic variables to be included and the functional form relating these variables. The initial formulation of a model is based on economic theory, our knowledge of the underlying behavior of the variables and other similar studies. One may also have some general idea of possible nonlinear effects as well as interactions among the variables.

Ordinary least square (OLS) is one most versatile and widely used statistical technique in empirical research. OLS analysis based on time series data implicitly assumes that the underlying series are stationary. Time series data is said to be stationary if its mean, variance and autocovariances are constant over time. In practice however, most economic time series such as price level and exchange rates exhibit strong stochastic trend and are nonstationary. In many cases, stationarity is achieved by simple differencing the series but recent research has shown that there are more enterprising ways to analyze nonstationary time series. Studies of cointegration and a related error correction technique are concerned with method of estimation that preserves the valuable information about time series data. Cointegration analysis estimates the long-run association of economic time series while error correction mechanism reconciles the short-run behavior of an economic variable with its long-run behavior.

The literature on unit root tests and cointegration regression continue to grow partly because the time series data have become so frequently and intensively used in economic research and partly because of the importance of nonstationarity problems in applied econometrics. It also due to the conviction that current unit root tests still has low "power of the test[54]". Although research into nonstationarity of the time series data continues to develop the important question, why some economic time series are stationary and some are nonstationary still remains puzzle.

[54] Power of the test is defined to be the probability of not making a type II error. Low power of the test implies a high probability of accepting a false hypothesis.

# *CHAPTER 5*
# *THE NATURE AND SOURCES OF DATA*

The success of any quantitative analysis depends on the availability of the appropriate data. This chapter examines the nature, coverage, construction, sources and limitations of the time series data that have been chosen for this study

## *5.1. Period and Nature of Canadian Imports*

### *5.1.1. Period Covered*

All series employed in this analysis covered the period from 1979 to 2000. Unless otherwise stated, all the series are quarterly observations with 1992 as a base year. One would have hoped for analysis that covers the entire period of floating era but because of the considerable effort involved in constructing the index and severe limitations in data availability in some variables, the study is constrained to this sample range. Nevertheless, the period covered is well suited for the study's purpose. Beginning from 1991, inflation-control targeting has been a cornerstone of monetary policy in Canada. In an economy where monetary policy is focused on controlling inflation, fluctuation in the exchange rate is expected to have less impact on the trend of domestic prices in the long run even though the same cannot be said in the short-run. Thus, the comparison made between 1979-89 and 1990-2000 is therefore considered appropriate.

### *5.1.2. Commodity-Coverage*

Canada's imports are generally grouped into six main economic categories. These categories comprise food and beverages, energy products, automotive products, industrial supplies, machinery and equipment, and other consumer goods. The automobiles imports and electrical appliances constitute over 90 percent of imports of consumer goods (exclude industrial and capital imports) and have very high import content in the Canadian domestic market. Besides, their prices, especially automobile prices, have exhibited large swings over the past decades. The pass-through analysis therefore concentrates specifically on automobile and electrical appliances imports[55]. It estimates the exchange rate pass-through effect on prices of automobiles and electrical appliances. The focus on these traded commodities is appropriate since the main purpose of this study is assessing the exchange rate impact so to speak on the "*ordinary consumer*". The growing perception that changes in exchange rates are now having less impact on prices than they had at the beginning of the floating era is also tested through estimation of timing and magnitude of the effect of exchange rate changes on consumer prices as well as prices of aggregate imports of manufactured products. If that perception is correct, then a depreciation of the Canadian dollar would be expected to be less likely to fuel inflation.

### *5.1.3. Sources of Canadian Imports*

No two other nations share as much as Canada and the United States. The two countries are highly integrated and share many important characteristics. They are in close geographic proximity, share similar values, culture and history. With the Free Trade

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[55] Electrical appliance component of manufactured imports comprises household appliances, audiovisual equipment, computers and all sorts of electronics.

Agreement of 1989 and the addition of Mexico in 1994 to form the North American Free Trade Agreement (NAFTA), tariffs between Canada and the U.S. have been eliminated on a large number of traded commodities. As Thiessen (2000) notes, the value of goods and services that crosses the U.S.-Canada border every year amounts to about US$370 billion representing about 40 percent of Canada's GDP. The United States accounts for almost two-thirds of Canada's net international liability position while Canada account for nearly 20 percent of the U.S. international trade in goods and services (Bank of Canada Report 2000). The imports of manufactured products accounts for over 90 percent of total Canadian imports and the United States alone accounts for over three-fourth of the total of this component. Table 5.1 shows distribution of Canadian imports by country for 1990-1998.

***Table 5.1: Share of total Canadian imports of manufactured goods by countries, 1990-1998***
***Selected Years (Percent)***

| *Countries* | *1990* | *1992* | *1995* | *1997* | *1998* |
|---|---|---|---|---|---|
| U.S | 64.5 | 65.2 | 66.8 | 67.6 | 72.5 |
| Japan | 7.0 | 7.6 | 5.4 | 4.6 | 4.6 |
| Mexico | 1.3 | 1.9 | 2.4 | 2.6 | 2.6 |
| U.K | 3.6 | 2.8 | 2.4 | 2.4 | 2.1 |
| China | 1.0 | 1.7 | 2.1 | 2.3 | 2.6 |
| Germany | 2.7 | 2.4 | 2.1 | 2.0 | 2.1 |
| France | 1.8 | 1.8 | 1.4 | 1.9 | 1.6 |
| Others | 18.1 | 16.6 | 17.4 | 16.6 | 11.9 |

Source: 1998 International Trade Statistics Yearbook, UN Volume I

In table 5.1, it can be argued that the distribution of imports across various countries not only shows the dominance of the United States in Canada's economic links but also it shows a substantial increase over the past ten years. Japan's share has fallen sharply, and the U.K. and Germany by a lesser amount while the U.S. share has risen commensurately.

In light of the dominant role of the United States in Canada's external activities, this analysis elects to examine the impact of Canada-U.S bilateral exchange rate changes on prices of manufactured imports from the United States. In short, the choice of United States in this pass-through analysis is dictated by the dominant role of the United States in Canada's international trade in goods and also by the data availability from the United States.

### *5.2. Construction and Sources of Data*

#### *5.2.1. Price Development and Exchange Rate Movements*

The price indexes for automobile imports and electrical appliances were constructed from data series maintained by the Statistics Canada (CANSIM). The series are all seasonally adjusted data at 1992 prices. For construction of the index for aggregate imports of manufactured goods, fixed-weighted averages of the 1990s' average share weights of import prices for industrial suppliers, capital goods, automotive products and consumer goods were used[56]. The fixed-weight index is preferred to the import price index constructed by Statistics Canada because the fixed-weight index measures price changes in the manufactured sector that exclude imports of services and other products whose prices have remained relatively stable over the sample period (*see Appendix figure A.2*). Figure 5.1 compares the price indexes constructed for automobiles, electrical appliances and aggregate imports of manufactured commodities.

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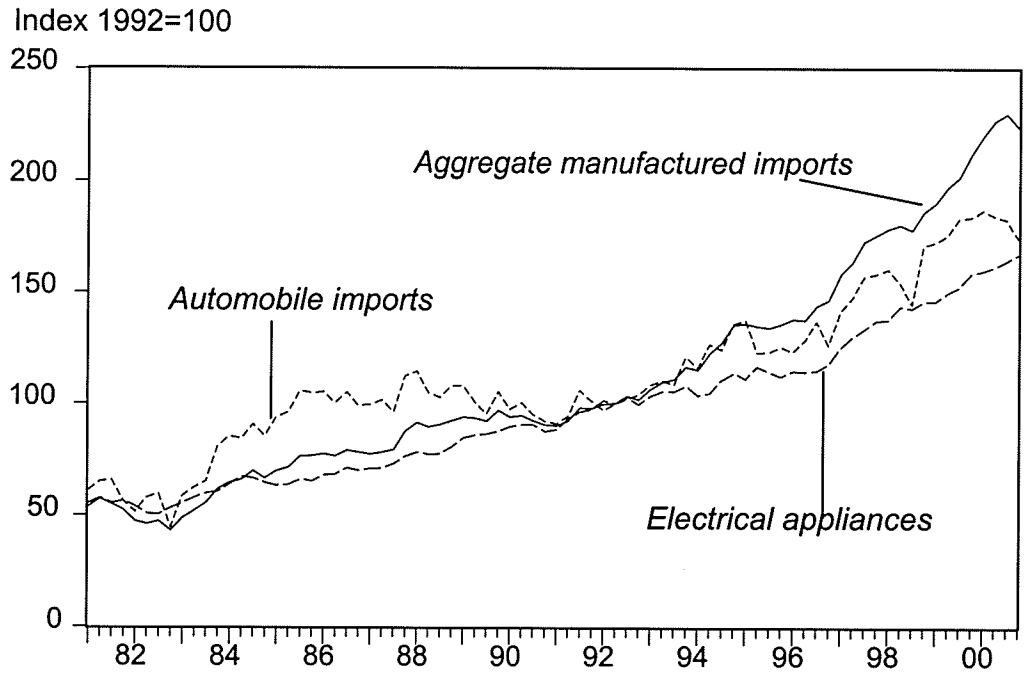
[56] The aggregate import of manufactured goods comprises industrial suppliers, capital goods, automotive products and consumer goods excluding food, forestry and petroleum products.

*Figure 5.1: Price development for selected imports in Canada, 1979-2000*

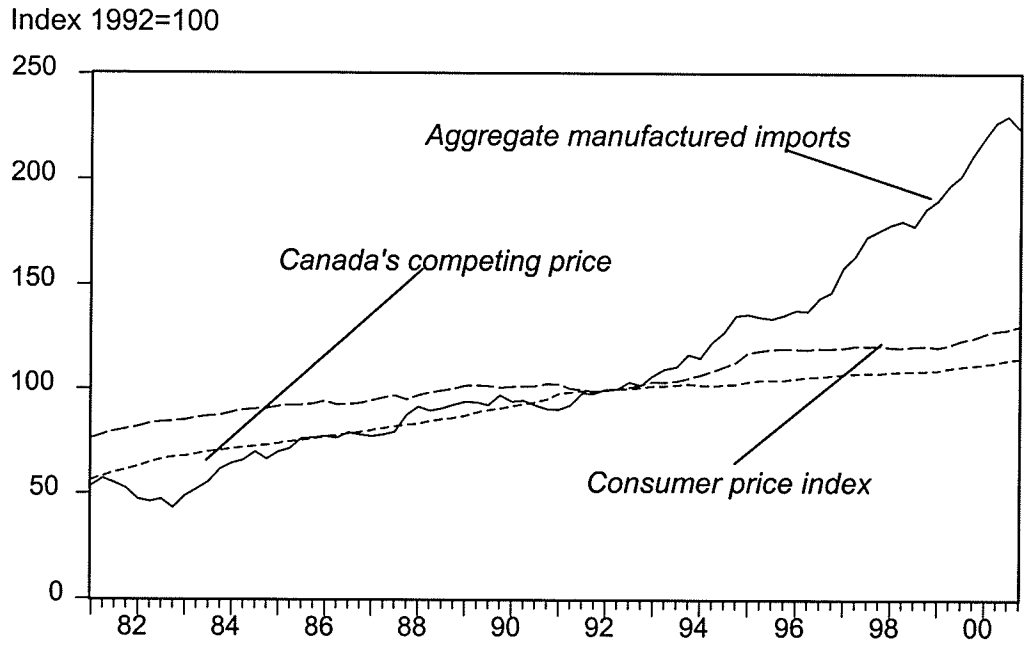



Sources: See text in Appendix A

The domestic "competing" price is the industry-selling price for various categories of the manufacturing output. The raw data for industry price for automobiles and various components of electrical appliances were available from CANSIM. For aggregate imports, the index was calculated as a weighted average of industry-selling prices for various manufacturing sectors weighted by each category's average share in Canada's imports in the 1990s. The industry-selling price is designed to monitor changes in ex-factory prices for the manufacturing sector and it is expected to measure the competitive pressures that a U.S. exporter faces in the Canadian (domestic) market. A lower value of the coefficient for the competing price will indicate that exporters face less competition in the Canadian market. As shown in figure 5.2, both the competing industry prices and consumer prices have been fairly stable while the prices of imported commodities exhibited large swings

upward. The quarterly data on the consumer price index and raw data for the construction of the competing price index were also obtained from the data series maintained by Statistics Canada (CANSIM). Figure 5.2 compares movements of prices indexes for aggregate imports, competing prices and consumer prices.

***Figure 5.2: CPI, import prices and competing price in Canada, 1979-2000***

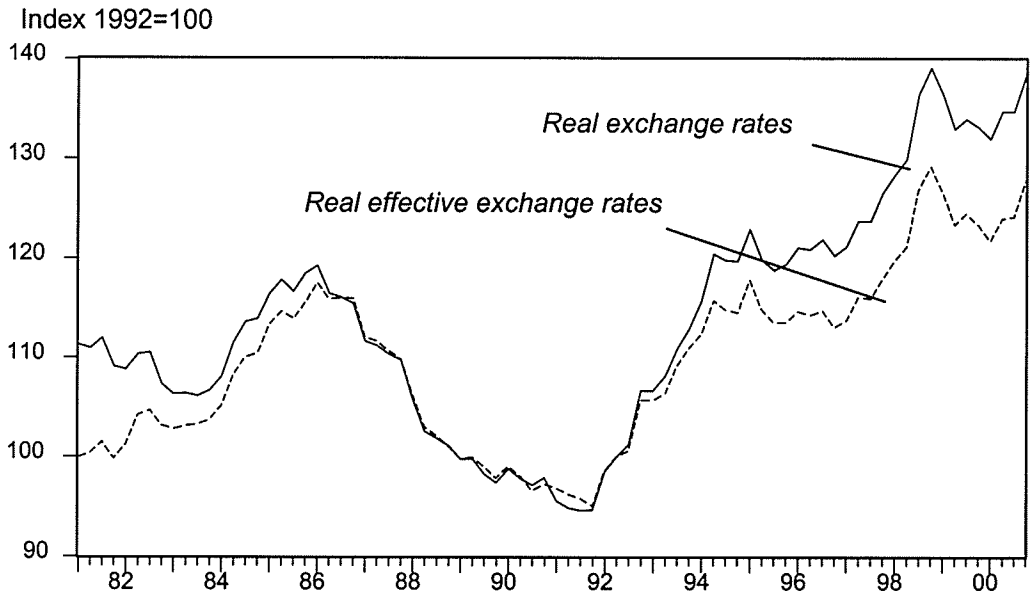



Sources: See text in Appendix A

The real exchange rate and real effective exchange rate were constructed for pass-through analysis and exchange rate-prices causality relationships, respectively. The real effective exchange rate index should ideally measure a change in a country's exchange rate that has taken place since the base period relative to the rest of the world. In order to effectively compute the real effective exchange rate, economic relationships among countries that influence the movement of the Canadian dollar have to be truly reflected in the weights. In this study, the quantity of exports plus imports within a group of seven countries (*see table*

*5.1*) was chosen to represent Canada's main trading partners. Trade weights were computed based on the trade patterns during 1990-1998 period obtained from the UN's 1998 international trade statistics yearbook. Monthly data on exchange rates (noon spot) were obtained from CANSIM for all countries except Mexico and China. Exchange rate data for Mexico and China were obtained from the IMF's international financial statistics in U.S. dollars (but transformed to Canadian dollars). The rising values represent currency depreciation. Figure 5.3 compares real exchange rates and real effective exchange rates for Canada.

***Figure 5.3: Real exchange rates and real effective exchange rate***

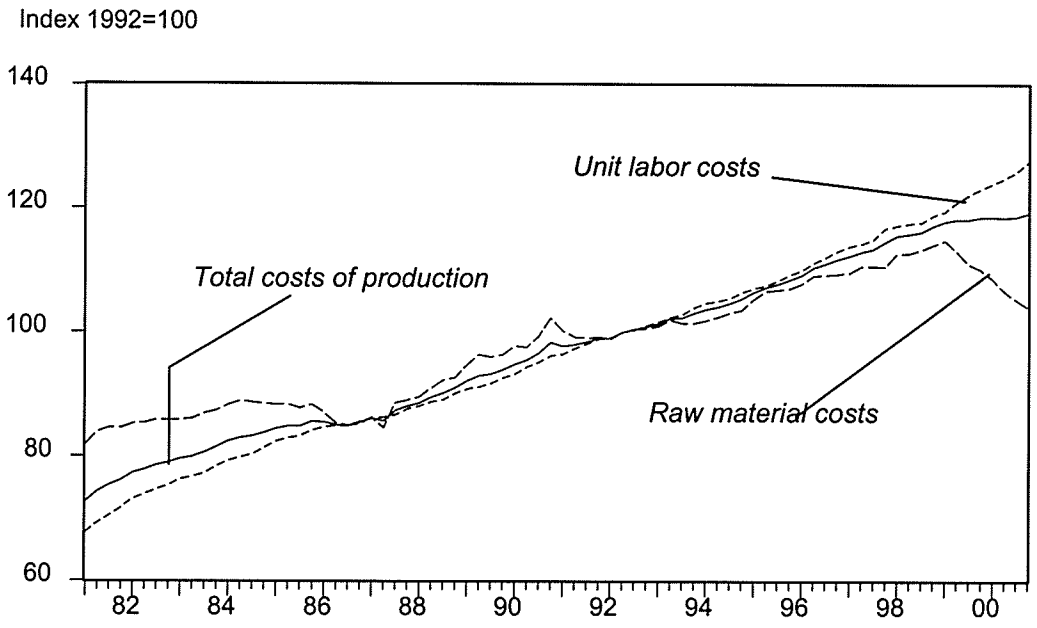



Sources: See text in Appendix A

### *5.2.2. Costs of Production and Capacity Utilization*

The cost of production index is a weighted average of unit labor cost, prices for raw materials and energy inputs into manufacturing sector in the United States. Unit labor costs represent wage rates in the manufacturing sector per specified time period. Weights of 65 percent for unit labor costs, 25 percent for raw materials and 10 percent for energy inputs were used for the construction of costs of production index. These weights were based on a recent U.S. Bureau of Labor Statistics (BLS) review of input-output tables for the U.S. economy (BLS Release 1998). The U.S. producer prices for raw materials, unit labor costs and energy were available from Bureau of Labor Statistics.

***Figure 5.4: U.S. Unit labor, raw material and total costs of production, 1979-2000***




Sources: See text in Appendix A

As indicated in figure 5.4, though the total costs of production in the U.S. have been increasing steadily, the cost has been held down by the declining raw materials prices particularly in the last few years reflecting downturn in material prices in the late 1990s.

The data on capacity utilization rates in the manufacturing sector were obtained from the U.S. national source maintained by the Federal Reserve Board. The capacity utilization variable is included as a proxy for "tightness" in market demand that could come from either domestic or foreign markets. When market demand increases, production increases more quickly than does capacity. In theory, if firms recognize that they are nearing the potential output of the factory, the supply curve becomes vertical. In this situation, the firms can take advantage of greater market power as they come close to full capacity by increasing mark-ups. However, if market demand falls, capacity becomes slack, and the firms are willing to cut mark-ups to maintain sales and market share. For this reason, the capacity utilization coefficient is expected to be positive.

### *5.3. Data Constraints*

The data selected for any exchange rate pass-through study can make a substantial difference to the analysis. Data constraints, particularly with respect to a suitable time series, have been a key factor inhibiting empirical research. While considerable effort has been involved in securing appropriate data, non-availability of data series for some of the variables still poses major problems. . First, the study employed capacity utilization as a measure of demand pressures but data for capacity utilization were not available for electrical appliance and automobile sectors. As a result, one series for capacity utilization is used for the pass-through equations; whether or not they are well suited to the task is not

so clear. Second, the construction of the real effective exchange rate concentrated on commodity trade alone. However, factors such as autonomous capital transactions, banking behavior, government policy actions and even expectations are known to have great impact on exchange rate movements but, due to lack of appropriate measure, they are all being neglected in the constructed index. Besides, weights used in various indexes were fixed but in reality, trade weights among trading partners do change over time. Third, empirical work based on time series data assumes that the underlying time series are stationary. A data series is stationary if its mean value and its variance do not vary systematically over time. However, unit root tests indicate that none of the data series selected for this analysis is stationary suggesting the presence of a stochastic trend in their levels. Finally, this analysis was limited to quarterly observations of a twenty-year period; a data range considered to be short in time series analysis. The main concern here is that most of the well known econometric tests developed for empirical analysis requires a relatively larger sample size. In addition, as one estimates successive lags in distributed–lag models, there are fewer degrees of freedom left. Loss of degree of freedom may reduce the power of tests performed on the coefficients.

# *CHAPTER 6*
# *ESTIMATION RESULTS*

## *Overview*

This chapter discusses the estimation procedures and results for the pass-through models as well as exchange rate-prices causality relationships discussed in chapter 4. There is no general formula as to how to proceed with empirical estimations. However, certain general guidelines are nevertheless useful. Therefore, the following steps were applied for the estimations. All the theoretical models were first estimated using the traditional ordinary least squares (OLS) techniques. To avoid hasty conclusions with the initial statistical output regarding the individual coefficients and overall significance of the estimated regression, the models were subjected to further analysis including serial correlation and heteroscedasticity tests. The identified econometric problems were treated with the usual remedial measures: White's heteroscedasticity-consistent variance procedure was adopted to deal with heteroscedasticity problem, a Cochrane-Orcutt iterative procedure in the form of AR process for serial correlation and Akaike information criterion for selection of optimum order of lags.

The problems associated with statistical properties of OLS estimators whenever the data are nonstationary are well known (Engle and Granger 1987, Johansen 1988, MacKinnon 1991). As a means to validate the stationarity of the time series data, unit root tests were applied to all the data series. Presence of cointegration was detected in two of the three pass-through equations in their first differenced form and the pass-through models were re-specified as error correction models in order to capture both the long run equilibrium relationships and short-run dynamics. To facilitate comparison, unconstrained distributed

lag (DL) model was also estimated for the first differenced form of the data with usual OLS techniques. The purpose is to see how these methods fare against other estimation procedures and also, to test for lags in pass-through analysis. Though different in their estimation procedures with slight variations in results, both approaches basically gave similar conclusions[57]. The following additional tests were also applied to the various equations:

- Testing that the partial regression coefficients satisfy certain restrictions. That is, testing that exchange rates and U.S. cost coefficients are equal as in equation 4.11.
- Testing the functional form of regression model using MWD test proposed by Mackinnon, White and Davidson (1983).
- Testing for the structural stability of the estimated regression over time.

The estimation results in various steps are presented in tables highlighting the salient features with special emphasis on the pass-through coefficients. Detailed results for estimations are contained in Appendix B. All estimations and testing were performed using Eviews3 and Shazam/8w statistical packages and reported at 5 percent significance level unless otherwise stated. This chapter is organized in two parts: The first part presents the results for the pass-through models. Specifically, it presents estimation results from distributed lag model and cointegration regressions. The second part detects causality-feedback relations between exchange rates and prices in Canada.

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[57] Polynomial distributed lags (PDL) with second-degree polynomial and a tailed constraint were also applied to the pass-through model. Both PDL and DL approaches yielded similar range of values for exchange rate pass-through coefficients.

### *6.1. Estimation Procedures and Results for the Pass-Through Model*

The initial set of results (not shown) is derived from OLS estimation procedures for equation 4.12. While the claims of higher pass-through of Canadian imports of manufactured goods by previous studies (Kleinin 1977, Spitaller 1980) seem to be confirmed by these results, these estimates cannot conveniently be used as a basis for statistical inferences. This is in part due to the fact that the structure of the estimated regression is based solely upon the theoretical foundations. It is not the "best" in terms of their goodness-of-fit. Many of the coefficients are not statistically significant and some of the signs are contrary to expectations. Besides, the estimated coefficients suffer from serious serial correlation problem. Both the Durbin-Watson (DW) test for first order and the Lagrange multiplier test for higher order autocorrelation indicate positive serial correlation problem while large values of Akaike information criteria signify model inadequacy.

The discrepancy in the initial results could also be attributed to the fact that the initial estimate suffers from the problems associated with nonstationary data series since in all cases the R-square is greater than DW statistic. As Granger and Newbold (1974) have suggested, an $R^2 > d$ statistic is a good rule of thumb to suspect that the estimated regression suffers from spurious regression or the data series are nonstationary.

#### *6.1.1. Testing For Stationarity: Unit Root Tests*

The statistical inferences of OLS estimates may be misleading if the time series data exhibits a stochastic trend such that the student t-statistic no longer displays an asymptotically normal distribution. It is therefore important that time series analysis is

performed on stationary variables. To validate the stationarity of the time series, we follow both augmented Dickey-Fuller (ADF) and Phillips-Perron unit root tests. The ADF and PP tests differ slightly in the sense that the ADF test includes a constant and a time variable in its specification to account for time trend in the series. The table 6.1 summarizes the unit root test under ADF and PP test statistic for various variables.

***Table 6.1: Unit root tests for stationary series***

Critical Values: 1% = -4.0380 5% = -3.4491 10% = -3.1495

| | Aggregate Imports | Auto Imports | Electrical Imports | Exchange Rates | U.S. Costs | Competing Price | Capacity Utilization |
|---|---|---|---|---|---|---|---|
| *Levels* | | | | | | | |
| *ADF Tests* | *-2.07* | *-2.89* | *-2.21* | *-1.46* | *-2.22* | *-2.95* | *-3.94* |
| *PP Tests* | *-2.27* | *-3.26* | *-3.04* | *-1.53* | *-1.27* | *-1.99* | *-3.12* |
| *1st diff* | | | | | | | |
| *ADF Tests* | *-5.59* | *-4.93* | *-5.83* | *-4.44* | *-3.33* | *-3.58* | *-3.35* |
| *PP Tests* | *-10.01* | *-13.42* | *-11.66* | *-8.06* | *-6.77* | *-5.72* | *-6.05* |

The tests results indicate the "likely presence" of unit root in all the data series at their levels, suggesting nonstationary of the variables. For their first differenced form, PP tests rejected the unit root hypothesis in all the variables at 1 percent significant level[58]. That is, the levels of all the variables are integrated of order one *I(1)* or their first differenced forms are integrated of order zero I(0) indicating stationary series of all the variables in their first differenced form. From table 6.1, it can be argued that the PP tests do not reject the integrated of order one transformation more readily than the ADF tests. Perron (1988)

[58] ADF tests do not reject unit root for some of the 1st differenced variables at 1 percent significance level but reject unit root for all variables at 10 percent level of significance.

attributed these differences to the inclusion of time variable and argued that the inclusion of a trend term in the ADF tests introduces bias in the tests statistic in favor for non-rejection of the unit root[59].

### *6.1.2. Testing For Cointegration: AEG Tests*

The estimation of the cointegration regression and error correction mechanism is based on Engle-Granger two-stage procedure. The cointegration relationships between the import prices and exchange rates, costs, and capacity utilization were estimated and tested using Eviews. Based on the results from Augmented Engle-Granger (AEG) tests on the cointegration residuals, cointegration in two of the three equations was not rejected at 5 percent significance level. The main results are summarized in table 6.2 below.

***Table 6.2: Result for the tests of cointegration***

| | ADF Test Statistic | PP Test Statistic | AEG Critical values at 5% |
|---|---|---|---|
| Automobiles | -3.5223 | -4.9728 | -3.4639 |
| Electrical appliances | -3.1891* | -3.3381* | -3.4665 |
| Aggregate imports | -3.5971 | -3.8901 | -3.4652 |

* Both tests reject cointegration hypothesis

[59] Perman (1991) has also noted that, the power of ADF tests is likely to be low for series where the disturbances are heterogeneously distributed while the non-parametric adjustments (PP tests) are likely to raise the power of the tests in these circumstances.

Cointegration relationships were present in automobile and aggregate imports equations but not in electrical appliances. The lack of cointegration in the electrical appliances category may be due in part to its relative competitiveness. Under competitive conditions, since "market forces" do not push prices towards a constant mark-up over costs, a strict long-term cointegrating relationship need not exist (Granger 1986). Given the presence of cointegrating relationships, the theoretically derived error correction mechanism is estimated for automobile and aggregate imports. The results for cointegration regressions for automobiles and aggregate imports with serial correlation specification are summarized in tables 6.3 and results for associated error correction mechanism in table 6.4.

***Table 6.3: Long-run coefficients from cointegration regression***

| | Coefficients | T-ratio | P-value | Adjusted $R^2$ |
|---|---|---|---|---|
| Automobiles | 0.78 | 3.9924 | 0.0037 | 0.9605 |
| Aggregate imports | 0.57 | 5.004 | 0.0000 | 0.9848 |

*Table 6.4: Short-run coefficients and speed of adjustments from error correction model*

| | Coefficients Short run | Speed of adjustment | T-ratio | Adjusted R-square |
|---|---|---|---|---|
| Automobiles | 0.41 | -0.33 | 2.08 | 0.6997 |
| Aggregate imports | 0.23 | -0.21 | 2.17 | 0.7298 |

### *6.1.3. Testing For Lags in Pass-Through Model*

To test for lags in pass-through, unconstrained distributed lag model were also applied to the pass-through equations with lags ranging from zero to twelve quarters. The estimates are for imports of automobile products, imports of electrical appliance and aggregate imports of manufactured goods. Akaike information criterion for model selection was used to identify the significant number of lags in all cases and the equation with lowest value of this criterion statistic is judge to be preferable. Significant lags were present in all cases and the best equation fits, as measured by the adjusted R-squares were generally obtained for lags in the range of two to four quarters. All estimations were performed with AR process with fourth-order serial correlation corrections. All the variables were in their first differenced form with quarterly data over the period 1979:1 to 2000:4. Table 6.5 summarizes the long-run pass-through coefficients for unconstrained distributed-lag models for various categories of manufactured imports.

*Table 6.5: Long-run pass-through coefficients from distributed-lag model*

| | Coefficients | Lag length | T-ratio | Adjusted $R^2$ |
|---|---|---|---|---|
| Automobiles | 0.83 | 2-3 | 2.600 | 0.7852 |
| Electrical appliances | -0.18 | 2 | -2.19 | 0.6898 |
| Aggregate imports | 0.62 | 4 | 3.00 | 0.8137 |

While the pass-through estimates vary depending on the commodity-coverage, the figures do impart a distinct impression. The estimate for the automobile imports has a significantly higher coefficient in the neighborhood of 41 percent to 52 percent. The foreign exporters in this sector passed almost half of the shocks into prices following a Canadian dollar depreciation. This is a short run effect where the period of adjustment is limited to first four months following a shock. This estimate is reasonably consistent with earlier studies by Knetter's (1989), Gagon and Knetter (1995) concerning the effects of currency depreciation on automobile imports. The U.S. exporters appear to be "price makers" on the buying side of the automobile market with long run pass-through ranging between 78 and 83 percent with lags extending to two to three quarters[60].

[60] One can argued that the "Big three" U.S. automobile exporters (General Motors, Ford and Chrysler) can afford to retain their prices in U.S. dollars given the preferential treatment in accordance with the 1965 United States-Canada Automotive Products Trade Agreement (Auto Pact). One of the provision of the Auto Pact ensures duty-free exchange of vehicles provided certain Canadian production quotas on behalf of the Big Three's Canadian subsidiaries are satisfied (Dunn 1987, Holmes 1992).

The short run results from the error correction model show that changes in Canada-US bilateral exchange rates have significant positive effects on prices of automobile imports and that about 33 percent of the discrepancy between the actual and the long-run or equilibrium value of automobile prices is eliminated or corrected each quarter. Even though the long-run pass-through relationship between exchange rates and automobile prices is less than complete, it can be argued that the speed at which the prices of automobile imports adjust to their long-run growth path is fairly quickly following a disturbance.

The assumption that the impact coefficient of exchange rates and U.S costs are equal was tested using Wald coefficient restrictions test. The null hypothesis that they are equal was rejected indicating differences in impact between exchange rates and production costs on import prices. The coefficient impact of the U.S costs is about 0.93 with lag extending to three to four quarters, suggesting that there is practically a one-to-one long-run relationship between automobile prices and cost of production. The capacity utilization term is statistically significant while Canada's competing price is statistically insignificant and has the wrong sign. The implication is that the exporter's profit margins do respond to demand pressure both at home and abroad and but faces less competition in Canada's domestic market. There is however a large discrepancy in the estimation results from the two techniques regarding the short-run coefficient impact of exchange rates. While the distributed lag model reports short-run impact of 52 percent, the estimates from the error correction model report a short-run impact of 41 percent; a difference of more than 10 percentage points.

The negative pass-through coefficient for the imports of electrical appliances indicates *prima facie*, tenuous relationship. However, it confirms anecdotal evidence suggesting that U.S. exporters "dumped" their audiovisual and household appliances on the Canadian market during the late 1980s and early 1990s (Duguay 1994, Lafleche 1996). The abolition of customs duties on trade between Canada and the United States has undoubtedly played a role in neutralizing some of the effects of the dollar fluctuations on the import prices on these products. Following the signing of free trade agreement between the two countries in 1989, customs duties on various goods were gradually removed while those on audiovisual, radio and major appliances are being phased out and expected to disappear completely by 2002. Import duties had previously ranged from 1.8 percent to 19.7 percent for various imports of manufactured goods (Department of Finance 1988).

The market share strategy may also provide a partial explanation. As noted by Lafleche (1996), the signing of free trade agreement occurred at a time when demand for consumer goods and services in Canada was sluggish. In this context, it is possible that exporters, anxious to maintain their market share, chose to absorb most of the depreciation-induced cost increases. The restructuring in retail trade that has taken place over the past decade may also have helped to offset the effects of exchange rate changes on these products. It has been observed that a significant restructuring of retail trade in the Canadian economy began at the end of 1980s, when U.S. "big-box" stores began to move into Canada. While these stores spread slowly, they have begun to proliferate in the past six years with more and more Canadian firms following suit in the hope of protecting their market shares. This development has occurred not only in the mass merchandising arena but also in more specialized sectors such as construction and home renovation materials, office suppliers,

computers and all sorts of electronics and household appliances. Such an entry of new firms into a market undoubtedly counteracts the effects of currency depreciation on prices of these consumer goods.

In the case of aggregate imports, the results suggest the long-run exchange rate impact of about 62 percent and costs impact of about 0.55 with lags extending to about four quarters, which is roughly the same as implied by cointegration regression. The short run pass-through impact hovered around 23 percent and about 14 percent of the discrepancy between the short run and long run value is corrected each quarter. These results appear to be lower than those from previous research on the pricing behavior of foreign exporters of Canadian imports, a finding that runs somewhat counter to anecdotal evidence. Unlike automobile imports, the capacity utilization term in both the distributed lag model and cointegration regression lies within zero and one as expected. The impact coefficient of Canada's competing price is positive and statistically significant at 5 percent level of significance. The implication here could be that U.S exporters take advantage of periods of rising Canadian competing prices to aggressively expand their market shares.

### *6.1.4. Testing for Structural Stability*

The stability of the pass-through coefficient in the import price equations and the pass-through equation itself has been a subject of discussion for some time now. The general perception is that the exchange rate pass-through impact on Canadian imports has fallen. Quite a significant number of studies have tested the constancy of the pass-through coefficient (Piggot and Reinhart, 1985, Baldwin 1988, Mann 1986, Marston 1989, and Moffet 1989). While these results are mixed and varied, the evidence seems to support the

structural break in both the import price equations and the pass-through coefficients. What is not clear is whether or not the same applies to Canadian economy.

In this study, the pass-through coefficients and import price equations for automobiles, electrical appliances and aggregate imports are tested for Canada. The equation's stability was tested by means of a succession of Chow breakpoint tests, run with the entire sample split at the end of each year starting from 1986:1 and going through 1995:4. The Chow breakpoint tests were run using the distributed-lag models with serial correlation corrections specification. Structural breaks were detected for all cases in the early 1990s. A structural break was detected in 1990:4 for electrical appliances, 1992:3 for automobiles and 1991:4 for aggregate imports. That is, within the sample period the structure of pass-through equations differs basically between the period from 1979 to1989 and the period from 1990 to 2000. The obvious question is: Are these breaks due to differences in the pass-through coefficients or differences in the intercept values? One problem with Chow breakpoint tests is that it does not explicitly tell us which intercept or slope is different, or whether both are different at different periods. In this respect, the dummy variable approach has a distinct advantage, for it not only tells us if two regressions are different but also it pinpoints the sources of the differences.

Using dummy variable techniques, the coefficients' constancy was tested by adding to the equations a second exchange rate term times a dummy variable to capture the slope differences and a second dummy to deal with difference stemming from the intercept. With Chow breakpoint years in mind, I used dummy variable equal to one for data series from

1990 to 2000 and zero otherwise. The coefficients of the exchange rate term with the dummy variables were all negative indicating a reduction in impact of exchange rate pass-through. The early breakpoint in the electrical imports equation suggests the evidence of a drastic reduction in pass-through effects on household appliances. This observation is partly comparable to studies by Mann 1986, Baldwin 1988, Marston 1989 and Moffet 1989 and seems to support the growing perception that movements in the exchange rates have less impact on import prices than they had in the beginning of the floating period, although the conclusion is not so clear-cut as Baldwin's taking into consideration the significance of the dummy variable terms.

### *6.2. Estimation Procedure and Results for Causality Detection*

This section presents the empirical estimations of equation 4.12 and 4.13 using monthly data on real effective exchange rate and consumer price index for the period 1986-2000. The purpose is to detect the direction of causality in a two variable framework between unanticipated fluctuations in exchange rates and unanticipated movements in consumer prices for Canada. All the variables are stationary in their first difference form. The ordinary least square estimation was applied to each autoregressive model. The difficulty was to determine the optimum number of lags in the right-hand side of the equations. To overcome this problem, this section again adopted the Akaike information criterion (AIC) criterion for model selection. Akaike criterion suggests that we select the regression equation that yields minimum values of its test statistic [61].

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[61] Akaike model selection criteria were applied in the study of money-income causality detection by Hsiao (1978), government expenditure-national income causality by Holmes and Hutton (1992), money-price causality by Frenkel (1977), wage-price linkage by Mehra (1977)

By considering single autoregressive process in equation *4.13*, I initially regressed $p_t$ on its own successive past values and a constant only and chose the optimum order of lags, which yields the minimum Akaike information criterion {say AIC(p)}. Then I regressed $p_t$ on its own past values whose order of lags is already determined and past values of $e_{t-i}$ to see if the inclusion of $e_{t-i}$ will improve the predictions of $p_t$. By varying the order of lags of $e_{t-i}$ starting from one, the optimum number of lags that yield minimum Akaike information criterion {say AIC(p,e)} were selected. If the value of AIC (p,e) < AIC(p), then we can conclude that the inclusion of past values of $e_{t-i}$ have improved the behavior of current values of $p_t$.. In other words, $e_{t-i}$ "weakly" causes $p_t$. If the *F*-statistic is significant at least at the 5 percent level of significance, then we say $e_{t-i}$ "strongly" causes $p_t$. The same estimation procedure was applied to equation *4.14*.

Table 6.6 and 6.7 report the coefficient estimates, the optimum orders of lags in months, value of Akaike information criterion (AIC) and the *F*-statistics in a two variable framework. The first rows represent coefficients, optimum order of lags, *F*-statistics and AIC when a variable is regressed on its own past values and a constant. The values in the second rows represent the respective statistics when a second variable is included in the regression. The general rule is that the model with lowest value of AIC is judged to be preferable.

***Table 6.6: Causality test from exchange rates to prices***

$$p_t = c_1 + \sum_{j=1}^{m} a_{1j} p_{t-j} + \sum_{j=1}^{n} a_{2j} e_{t-j} + u_t$$

| | Coefficients | Lag length | F-Statistic | AIC |
|---|---|---|---|---|
| $\Delta p$ | 0.63 | 15 months | 9.2568 | AIC(p) = -7.8522* |
| $\Delta e$ | 0.11 | 9 months | 13.5378 | AIC(p,e) = -7.8991 |

*AIC(p,e) < AIC(p) Adjusted R-Square = 0.6380

***Table 6.7: Causality test from prices to exchange rates***

$$e_t = c_2 + \sum_{j-1}^{m} a_{3j} e_{t-j} + \sum_{j-1}^{n} a_{4j} p_{t-j} + v_t$$

| | Coefficients | Lag length | F-Statistic | AIC |
|---|---|---|---|---|
| $\Delta e$ | 0.57 | 12 months | 7.7123 | AIC(e) = -4.7670* |
| $\Delta p$ | 0.14 | -- | 4.40079 | AIC(e,p) = -4.7307 |

*AIC(e,p) > AIC(e) Adjusted R-Square = 0.4635

The Δ denotes first differenced form of the variables. The estimated results show that there does not exist bi-directional causality between exchange rates and prices in Canada for the sample period. While unanticipated movements in exchange rate causes changes in the prices, the inclusion of past values of prices do not improve the predictions of exchange rate suggesting lack of causality from prices to exchange rates. The Granger causality test shown in table 6.8 also supports the view that changes in prices do not cause changes in exchange rate.

***Table 6.8: Granger causality tests***

| Null Hypothesis | F-Statistic | Probability |
|---|---|---|
| Δe does not Granger Cause Δp | 2.72618 | 0.04609 |
| Δp does not Granger Cause Δe | 1.06261 | 0.37357 |

It is expected that a "small" open economy such as Canada should exhibit bi-directional causality between exchange rates and prices but this estimate does not disclose any sign of feedback relationship. This observation is comparable to Brillemboug's (1976) and Frenkel's (1978) conclusions but contradicts findings by Kawai (1984). Brillembourg concludes: "There does not seem to be any causal relationship between exchange rate and prices". Frenkel finds that " prices do not 'cause' exchange rate (in the Granger sense) whiles exchange rates do 'cause' prices".

From the estimated results it is clear that the degree of causality from exchange rates to prices is not only low but also the speed with which it is passed on to consumers is very slow. Exchange rate changes appear to be passed onto consumer prices gradually, with lags extending to several months. Many reasons could be explored to explain this phenomenon. The magnitude of the depreciation-induced cost increase and the speed with which it is passed onto consumer prices usually depends on the relative share of imports in the CPI basket and also on other factors such as demand conditions, the cost of adjusting prices and expectations as to whether the depreciation is a temporary or a lasting phenomenon. Firms choose to change neither prices nor output if they believe that the depreciation is temporary particularly when they face costs in adjusting prices. Firms will change their actual selling price only if the desired adjustment is large enough to warrant paying the adjustment cost.

Although the relative share of imports in the consumer basket has risen over the past decades and one would have expecting corresponding increase in impact, the abolition of custom duties on trade between Canada and the United States may have helped neutralize the possible impact of currency depreciation on prices. In addition and more importantly, inflation-control targeting has been a cornerstone of monetary policy in Canada over the past decade. In an economy where monetary policy is focused on controlling inflation, movements in the exchange rate should have no impact on the trend of consumer prices though there may be short-run increase in imported inputs that may translate into higher production costs.

### *6.3. Summary*

The pass-through estimates suggest that if the Canadian dollar depreciates by 10 percent against its U.S. counterpart, other things being equal, it will raise automobile import prices by about 5 percent point initially and about 8 percent point within 2 to 3 quarters. On average, aggregate import prices will increase by about 2 percent initially and about 6 percent within 4 quarters while prices of electrical imports will have no significant impact. The sample data has revealed that the behavior of U.S. automobile exporters to Canada differs noticeably from electrical imports. It also differs significantly from the average for the aggregate imports.

For the impact on aggregate price levels, exchange rate changes appear to be passed onto prices gradually, with lags extending to several months. Even though a causality-feedback relationship is expected for an open economy such as Canada, the lack of feedback relation is not surprising. This is because price changes usually put pressure on the current exchange rates if the public comes to believe that the central bank policy is not likely to be directed towards restraining the higher rate of inflation induced by the depreciation.

## *CHAPTER 7*
## *SUMMARY AND CONCLUSION*

The study has examined the impact of exchange rate changes on consumers by analyzing the pass-through effect of prices of manufactured imports as well as exchange rate-prices causal relationships. It has measured the magnitude and the timing at which changes in exchange rates are transmitted onto prices of automobiles and electrical appliances imported into Canada from the United States over the period 1979-2000. The theoretical specification of the pass-through effects takes the form of mark-up model where firms maximize profits with respect to prices, subject to linear demand and supply curves. It is a partial equilibrium model in that exchange rate pass-through is defined as a partial derivative that reflects the willingness of foreign firms to adjust their profit margins to offset changes in exchange rates. In estimating the degree and the speed of pass-through effect on prices for manufactured imports, the partial adjustment models for cointegration regression were re-specified as an error correction models to separate the short-run dynamics from long run equilibrium relationships. Distributed-lag models were also applied to the pass-through equations to test for lags in pass-through while exchange rate–prices causality relationships were estimated using vector autoregressive specification and minimum Akaike information criterion.

The pass-through estimates indicate that, regardless of which estimation technique is employed, U.S firms passed larger amount of a change in exchange rate onto the prices of automobile imports than average of other categories of manufactured imports. The estimated result has shown that the portion of exchange rate changes transmitted into

prices of automobiles imports has significant initial effect of over 40 percent and long run effect ranges from 78 percent to 83 percent with lags extending to 2-3 quarters. Short-run adjustments from error correction mechanism suggest that the prices of automobile imports adjust fairly quickly to its long-run growth path following a disturbance. The short run impact of exchange rate changes on prices of aggregate imports hovered around 23 percent and long run pass-through generally ranges from 50–60 percent while that of electrical appliances has no significant impact. These estimates are indeed lower and run counter to the findings from previous studies on the pricing behavior of foreign exporters. However, it appeared to support the evidence that the exchange rate pass-through relationship has fallen over the past decade.

The estimates have also shown not only are exchange rate changes never reflected fully in prices of manufactured imports but also it varies substantially across industries or product categories. The results suggest that foreign exporters of electrical appliances on average sustain substantial shifts in the profit margins on their supplies to Canada as exchange rate changes. Whether or not the shift in profit margins is permanent is reserved for future studies but firms may be willing to sustain temporary lower profits on export sales to maintain market shares so long as profits on total sales are adequate.

These results are partial-equilibrium estimates; the full effects would depend on what the decline in the currency will do to the other determinants of import prices. Besides, one has to take cognizance of the fact that the result for electrical and automobile imports makes it unclear whether or not the pass-through estimates for aggregate imports are good reflection

of other components of manufactured imports namely machinery and equipment, industrial suppliers and other capital goods. More specific analysis should be presented for these categories of manufactured imports and even subcategories within each of these components.

The exchange rate-prices causality tests show that there does not exist a significant bi-directional causal relationship between exchange rates and prices in Canada. Causation *(in Granger sense)* from exchange rates to changes in the CPI is observed in about 9 to 11 percentage points whereas a change in price does not seem to cause a significant change in exchange rates. The lack of causation from prices to exchange rate is not a surprising because price changes will put undue pressure on the current exchange rates when individuals are convinced that the central bank policy is not likely to be directed towards restraining the higher rate of inflation induced by the depreciation. Though exchange rate movements appeared to influences aggregate price levels, the degree of impact not only is small, but also the speed with which exchange rate changes transmitted into prices levels is gradual with lags extending to several months.

All in all, the evidence in this study is overwhelming in support of the view that the effect of exchange rate changes in Canada is now less than they had at the beginning of the floating era. The absence of causation from prices to exchange rate supports the debating view that purchasing power-parity theory only cannot provide adequate explanation for exchange rate behavior. At best, identifies only one of the factors that affect exchange rate movements. For those pegged economies that are concerned with the impact of exchange

rate depreciation upon domestic inflation, the evidence in the study does not support the "vicious circle" hypothesis that floating exchange rate is the main source of dynamic instability of the economic system. One can argue that exchange rate changes will have minimal impact on aggregate prices if the general public comes to believe that the national economic policy is capable of containing instabilities that may be induced by the depreciation. Public expectations of the future course of monetary policy thus play a key role in the interactions between the exchange rate changes and prices.

*Limitations and Direction for Future Studies*

Like other studies, this study also suffers from many drawbacks, some of which are already discussed in chapter five. First and foremost this analysis employed distributed-lag model. One major problem was that the inclusion of successive lag values tend to be highly correlated leading to problem of multicollinearity. As a result the estimated standard errors were larger in relation to the estimated coefficients, making most of the lagged coefficients statistically insignificant. One striking feature in the exchange rate pass-through studies is the differences in estimations obtained by different authors studying the same country, commodity and even at the same period. These differences in the estimations highlight the importance of the choice of data for the import prices, costs and all other variables affecting import prices. It also highlights the importance of the methodology employed in pass-through studies.

In this study, the pass-through model is a partial equilibrium model where pass-through is defined as a partial derivative of import prices with respect to exchange rates. It ignores the

impact of exchange rate changes on costs. In particular if a portion of raw materials used in manufacturing sector in U.S are exported from Canada then one can argue that depreciation of Canada-U.S bilateral exchange rate can affect U.S costs of production; a situation that may lead to a different estimate(s) of pass-through effect from the one indicated by partial equilibrium model. Future research in this area should pay particular attention to the methodology employed. A more complete model should express foreign costs as a function of the exchange rate and other factors rather than treating costs as an exogenous variable. In addition, one should use appropriate cost indices for each of the import categories rather than one cost index for all categories. The lack of causation may reflect the fact that the weight of the goods traded in international transactions has declined to a point where goods prices are not significant determinant of the exchange rate. Other variables such as capital transactions, banking behavior or money supply and even expectations need to be considered in the causality equation.

## *APPENDIX A*

### *A.1: Summary of Sources of Raw Data*

*United States*

Capacity utilization (Federal Reserve Board); prices of raw material and energy, Unit Labor costs (Bureau of Labor Statistics); consumer price index, exchange rates (Statistics Canada - CANSIM)

*United Kingdom*

Exchange rates, consumer price index (Statistics Canada - CANSIM)

*Canada:*

Import prices, Industry-selling price, consumer price index (Statistics Canada – CANSIM)

*China*

Exchange rate s (U.S dollars), consumer price index (International Financial Statistics)

*Mexico*

Exchange rates (U.S dollars), consumer price index (International Financial Statistics)

*France*

Exchange rates, consumer price index (Statistics Canada - CANSIM)

*Germany*

Exchange rates, consumer price index (Statistics Canada - CANSIM)

*Japan*

Exchange rates, consumer price index (Statistics Canada - CANSIM)

*A.2: Weights for constructed data series*

***Aggregate manufactured import price index*:** The fixed weight index was computed as the weighted average of fixed-weight import price indexes for various categories of manufactured imports, weighted by average share in Canada's imports in 1990s. The weight and categories are: Weights of 30.5 percent for Machinery and equipment, 25 percent for industrial suppliers, 29.5 percent for automobile products and 15 percent for consumer goods excluding food and beverages.

***Price index for electrical appliances*:** The fixed weight index was calculated as the weighted average of fixed weight import prices for two major categories. The weights and categories are 80 percent for audiovisual equipment including computers and all sorts of electronics and 20 percent for household appliances.

***U.S production costs in manufacturing sector*:** Weights of 65 percent for unit labor costs, 25 percent for raw materials and 10 percent for energy inputs were used for the construction of costs of production index. These weights were based on recent BLS review of input-output table for the U.S. economy.

***Real effective exchange rates index:*** Weights of 82.3 percent for the U.S, 5.2 percent for Japan, 3 percent for China, 3 percent for Mexico, 2.4 percent for the U.K, 2.4 percent for the Germany and 1.8 percent for the France. Weights based on total merchandise exports and imports from 1998 International Statistics Yearbook, UN Volume I.

*Figure A.2: Import prices by types*

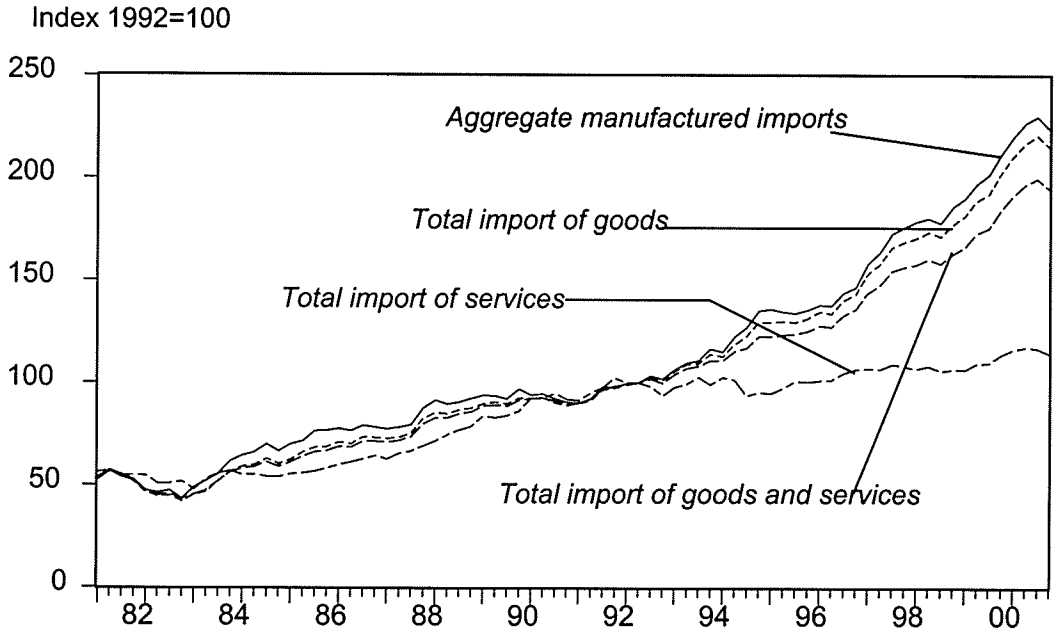
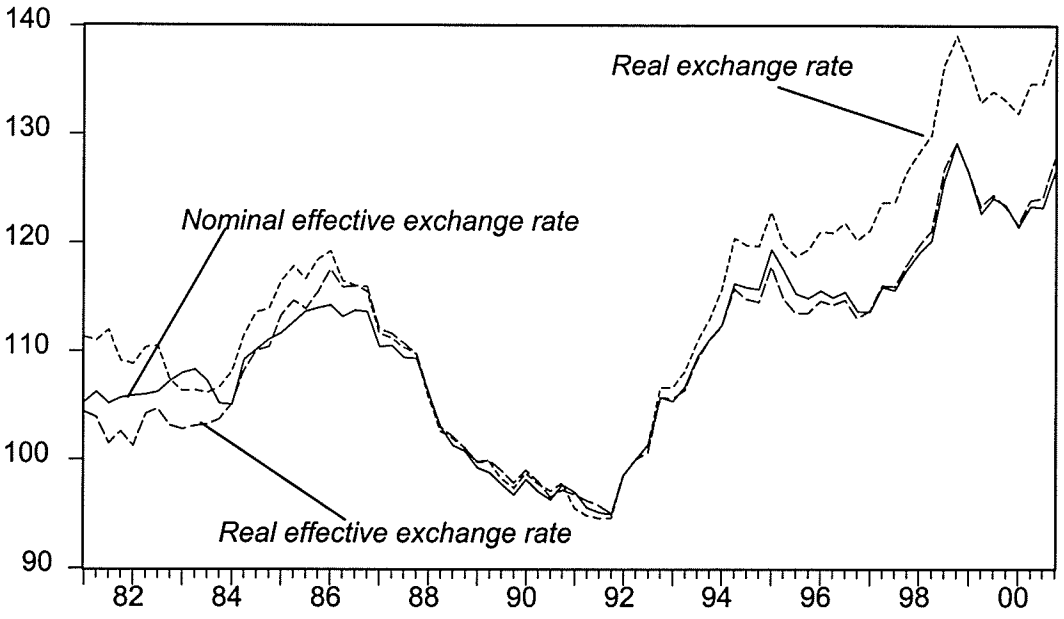



*Figure A.3: Movements of real and nominal effective exchange Rates*



*APPENDIX B*

***Table B.1: Results for cointegration regression***

***Dependent Variable: Automobile import***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| e | 0.782452 | 0.276182 | 3.992412 | 0.0037 |
| $c^*$ | 0.932505 | 0.532298 | 3.054313 | 0.0031 |
| $p^c$ | -0.333265 | 0.638269 | -0.522139 | 0.6031 |
| $c^u$ | 0.137867 | 0.743522 | 4.220271 | 0.0001 |
| C | -15.21594 | 2.723727 | -5.586441 | 0.0000 |
| AR(4) | 0.686515 | 0.078943 | 8.696313 | 0.0000 |

*R-squared =0.96291 Adjusted R-squared= 0.960532*

***Dependent Variable: Aggregate manufactured imports***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| e | 0.570709 | 0.108055 | 5.004041 | 0.0000 |
| $c^*$ | 0.561396 | 0.292117 | 8.494536 | 0.0000 |
| $p^c$ | 0.194360 | 0.346371 | 0.561132 | 0.5763 |
| $c^u$ | 0.896710 | 0.210651 | 9.004038 | 0.0000 |
| C | -16.10006 | 1.103348 | -14.59200 | 0.0000 |
| AR(4) | 0.526562 | 0.057251 | 9.197473 | 0.0000 |

*R-squared =0.985747 Adjusted R-squared= 0.984833*

*Table B.2: Results for error correction mechanism*

***Dependent Variable: Automobile imports***

| *Variable*[62] | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| $\Delta e$ | 0.413751 | 0.201487 | 2.080361 | 0.0534 |
| $\Delta c^*$ | 0.502618 | 1.350318 | -0.150052 | 0.0611 |
| $\Delta p^c$ | -0.923210 | 0.651918 | -1.416145 | 0.1609 |
| $\Delta c^u$ | 0.458189 | 0.596064 | 5.801706 | 0.0000 |
| C | 0.020106 | 0.011684 | 1.720803 | 0.0894 |
| $u_{t-1}$ | -0.335055 | 0.288543 | -1.715703 | 0.0403 |
| AR(4) | -0.115835 | 0.330298 | -0.350700 | 0.7268 |

*R-squared =0.7092 Adjusted R-squared= 0.69982*

***Dependent Variable: Aggregate manufactured imports***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| $\Delta e$ | 0.231399 | 0.183995 | 2.170651 | 0.0315 |
| $\Delta c^*$ | 0.286600 | 0.859903 | 1.263632 | 0.1004 |
| $\Delta p^c$ | 0.441431 | 0.335440 | 1.915977 | 0.0924 |
| $\Delta c^u$ | 2.166947 | 0.288309 | 7.516054 | 0.0000 |
| C | 0.026953 | 0.005946 | 4.532993 | 0.0000 |
| $u_{t-1}$ | -0.218205 | 0.054120 | -4.216666 | 0.0001 |
| AR(4) | -0.014908 | 0.129464 | -0.115148 | 0.9086 |

*R-squared =0.7391 Adjusted R-squared= 0.72989*

[62] $\Delta$ denotes first differenced form of the variable

*Table B.3: Results for distributed-lag models*

***Dependent Variable: Automobile imports***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| $\Delta e_{t-3}$ | 0.858883 | 0.334169 | 2.660846 | 0.0118 |
| $\Delta c^{*}_{t-3}$ | 0.778528 | 1.730362 | 1.519043 | 0.1031 |
| $\Delta p^{c}$ | -2.172973 | 2.615934 | -0.527931 | 0.2317 |
| $\Delta c^{u}$ | 1.317436 | 0.516083 | 6.428109 | 0.0000 |
| C | 0.008765 | 0.008828 | 0.992909 | 0.3241 |
| AR(4) | -0.466051 | 0.130624 | -3.567874 | 0.0006 |

*R-squared =0.785203 Adjusted R-squared= 0.782228*

***Dependent Variable: Electrical imports***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| $\Delta e_{t-2}$ | -0.132837 | 0.035688 | -3.088215 | 0.0081 |
| $\Delta c^{*}_{t-2}$ | 0.477810 | 0.329228 | 1.755048 | 0.0635 |
| $\Delta p^{c}$ | 0.920573 | 0.072089 | 0.285385 | 0.1102 |
| $\Delta c^{u}$ | -0.152707 | 0.060867 | -2.508859 | 0.0144 |
| C | 0.004582 | 0.002149 | 2.132042 | 0.0364 |
| AR(4) | 0.372262 | 0.110831 | 3.358823 | 0.0013 |

*R-squared =0.692384 Adjusted R-squared= 0.689811*

***Dependent Variable: Aggregate manufactured imports***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| $\Delta e_{t-4}$ | 0.644027 | 0.213453 | 3.210839 | 0.0045 |
| $\Delta c^{*}_{t-4}$ | 0.559335 | 0.767984 | 2.206992 | 0.0308 |
| $\Delta p^{c}$ | 0.654723 | 0.408657 | 2.091540 | 0.0403 |
| $\Delta c^{u}$ | 0.186689 | 0.216116 | 10.11811 | 0.0000 |
| C | 0.015384 | 0.003840 | 4.006184 | 0.0002 |
| AR(4) | -0.418757 | 0.102263 | -4.094889 | 0.0001 |

*R-squared =0.8203 Adjusted R-squared= 0.817921*

***Table B.4 Exchange rate-prices causality tests***

***Dependent Variable: $\Delta p$***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| $\Delta p_{t-15}$ | 0.632399 | 0.140200 | 2.617680 | 0.0109 |
| $\Delta e_{t-9}$ | 0.115484 | 0.019708 | 1.800451 | 0.0763 |
| C | 0.003036 | 0.000901 | 3.370304 | 0.0012 |

*R-squared=0.641661* *AIC=-7.899173*
*Adjusted R-squared=0.638079* *F-statistic=9.496118*

***Dependent Variable: $\Delta e$***

| *Variable* | *Coefficient* | *Std. Error* | *t-Statistic* | *Prob.* |
|---|---|---|---|---|
| $\Delta e_{t-12}$ | 0.572325 | 0.112793 | 1.654576 | 0.1024 |
| $\Delta p_{t-1}$ | 0.141916 | 0.343988 | 1.799236 | 0.1262 |
| C | -0.005747 | 0.004020 | -1.429656 | 0.0572 |

*R-squared=0.488674* *AIC=--4.750602*
*Adjusted R-squared=0.463529* *F-statistic=4.400791*

## *REFERENCES*


Adler, M. and Lehmann, B. (1983) "Deviations from PPP in the long run." *Journal of Finance* XXXVIII, 5: 1471-87

Alterman, W. (1991) "Price Trends in U.S. Trade: New Data. New Insights." In P. Hooper And J. D. Richardson (eds) *International Economic Transactions: Issues in Measurement and Empirical Research*: 109-39

Adler, M. and B. Lehmann (1983) "Deviation from PPP in the Long run." *Journal of Finance* XXXVIII (5): 1471-87

Akaike, H. (1970) "Statistical Prediction Identification." *Annals of the Institute of Statistical Mathematics* 22(2): 203-17

Akaike, H. (1969) "Fitting Autoregressive Models for Prediction." *Annals of the Institute of Statistical Mathematics* 21, no. 2:243-47

Amano, R. A and R. T, Macklem (1997) "Menu Costs, Relative Prices, and Inflation: Evidence for Canada." *Bank of Canada Working Paper* 97-14: June 1997

Appleyard and Field (2001) "International Economics" 4th Edition, McGraw-Hill, Irwin.

Anti- inflation Board (1979) Inflation and Public Policy, Anti- inflation Board, Canada

Athukorala, P. (1991) "Exchange Rate Pass-Through: The Case of Korea Exports of Manufactures." *Economics Letters* 35:79-84

Athukorala, P. and J. Menon (1994) "Pricing to Market Behavior and Exchange Rate Pass-Through in Japanese Exports." *Economic Journal* 104:271-81

Balassa, B. (1964) "The Purchasing Power Parity Doctrine: Reappraisal." *Journal of Political Economy* 72: 584-596.

Baldwin, R. (1988) "Hysteresis in Import Prices: The Beachhead Effect." *American Economic Review* 78: 773-85

Bank of Canada (1990) "The Story of Canada's Currency". 4th ed. Ottawa: *Bank of Canada* Bank of Canada (1990) *Annual Report,* Various issues.

Basevi, G., and De Grauwe (1977) "Vicious and Virtuous Circle" *European Economic Review* 10

Ball, L. and N. G. Mankiw. 1995. "Relative-price changes as aggregate supply shocks." *Quarterly Journal of Economics* 110: 161–193.

Bernhofen, D. M. and Xu,-Pend (2000) "Exchange Rates and Market Power: Evidence from The Petrochemical Industry." *Journal of International Economics* 52(2): 283- 97

Bhagwati J. N. (1988) "The Pass-Through Puzzle: The Missing Prince from Hamlet."Columbia University (December)

Bigman, D. and T. Taya, (1984) (editor) "Floating Exchange Rates and the State of World Trade and Payments." 1984

Bigman, D. (1978) "Exchange Rate Determination in the Short Run". *DM/78/48, IMF*, Washington, D.C.

Bilson, J. O. (1978) "Monetary Approach to the Exchange Rate-Some Empirical Evidence". *IMF Staff Papers* 25:48-75

Binhammer, H.H. and P. Sephton, (1998) "Money, Banking and the Canadian Financial System." 7th ed. Toronto: International Thomson Publishing.

Bordo, M. and F. E. Kydland (1992) "The Gold Standard as a Rule," Federal Reserve Bank of Cleveland *Working Paper 9205*

Branson, W. H. (1972) "The Trade Effects of the 1971 Currency Realignments." *Brookings Paper on Economic Activities* 1: 15-65

Branson, W. H. (1977) "Asset Markets and Relative Prices in Exchange Rate Determination." *Sozialwissenschaftliche Annalen* 1: 69-89

Branson, W. H. and D. W. Henderson, (1985) "The Specification and Influence of Asset Markets" in W. R. Jones and P. B. Kenen, eds., *Handbook of International Economics* Vol. II (Amsterdam: North-Holland, 1985 pp. 749-805)

Brellembourg, A. (1976) "PPP Test for Causality and Equilibrium." *IMF, Dec. Issue*

Breusch, T. S. and A. R. Pagan (1979) "A Simple Test for Heteroscedasticity and Random Coefficient Variation", *Econometrica* 47: 1287-1294

Brown, R.L., J. Durbin, and J.M. Evans (1975) "Techniques for Testing the Constancy of Regression Relationships Over Time," *Journal of the Royal Statistical Society*, Series B, 37: 149–192

Caramazza, F. (1986) "The Interaction between Exchange Rate Changes and Inflation" *Bank of Canada Review* (July): 3- 14.

Carbaugh, R. (1992) "International Economics." *4th edition* :1992

Carse, S., Williamson, J. and G. Wood (1980) "Financing Procedures of British Foreign Trade." Cambridge University Press.

Cassel, G. (1918) "Abnormal Deviations in International Exchanges." *Economics Journal,* 28: (December), 413-15

Clarke, L. J (1991) "The Exchange Rate and the Price level of a Small Open Economy." *Journal of Policy Modeling* 13(2): 309-15

Cowling, K. and R. Sugden (1989) "Exchange Rate Adjustment and Oligoply Pricing Behavior." *Cambridge Journal of Economics* 13: 373-93

Clinton, K. and Zelmer, M. (1997) "Constraints on the Conduct of Canadian Monetary Policy In the 1990s: Dealing with Uncertainty in Financial Markets" *Technical Report* No. 80, December 1997

Darrat A.F (1986) "Money, Inflation and Causality in the North African Countries: An Empirical Investigation." *Journal of Macroeconomics* 16:5-18

Davidson, R. and J. G. MacKinnon (1989) "Testing for Consistency using Artificial Regressions," *Econometric Theory* 5: 363–384

Davidson, R. and J. G. MacKinnon (1993) "Estimation and Inference in Econometrics" Oxford University Press.

De Brouser, Ericsson, G. and D. Flood (1994) "Modeling and Forecasting Inflation in Australia" Reserve Bank of Australia, Mimeo.

Dickey, D.A. and W.A. Fuller (1979) "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association*, 74: 427–431

Dixit, A. K. (1989) "Hysteresis, Import Penetration and Exchange Rate Pass-Through." *Quarterly Journal of Economics* 104:205-28

Dominque, G. and S. Nicolas (2000) "Exchange Rate Pass-through and Dynamic Oligopoly: An Empirical Investigation" *Journal-of-International-Economics* 52(1): 89-112.

Dornbusch, R. (1987) "Exchange rate and Prices" *The American Economic Review* 77(1): 93-106

Dornbusch, R. (1984) "Monetary Policy under Exchange Rate Flexibility." Massachusetts Institute of Technology

Dornbusch, R. (1983) "Flexible Exchange Rates, and Interdependence." *IMF Staff Paper* 30:3-30

Dornbusch, R. (1976a) "The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy"...In the economics of exchange rate, edited by Frenkel and Johnson (1978)

Dornbusch, R. (1976b) "Expectations and Exchange Rate Dynamics." *Journal of Political Economy* 84: 6, pp 1161-76

Duguay, P. (1994) "Empirical Evidence on the Strength of the Monetary Transmission Mechanism in Canada." *Journal of Monetary Economics* 33: 39- 61.

Dunn, R. M. (1970) "Flexible Exchange Rate and Oligopoly Pricing." *Journal of Political Economy* 78: 140-51

Durbin, J and G. Watson (1950) "Testing for Serial Correlation in Least Square Regression." *Biometrica* 37: 409-428

Dwyer, J. and R. Lam (1995) "The Two Stages of Exchange Rate Pass-Through: Implications For Inflation" *Australian Economic Papers* 34 (65): 157-79

Engle, R. F. (1982) "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflation," *Econometrica*, 50: 987–1008.

Engle, R. F. and C.W.J. Granger (1987) "Co-integration and Error Correction: Representation, Estimation, and Testing," *Econometrica* 55, 251–276.

Feenstra, R. C. (1989) "Symmetric Pass-Through of Tariff and Exchange Rates Under Imperfect Competition: An empirical Test." *Journal of International Economic* 27: 25-45

Fenton, P. (1993) "Historical Overview of the Canadian Exchange Rate." *Bank of Canada Memorandum* 1 December.

Fienberg, R. M. (1986) "The Interaction Foreign Exchange and Market Power Effects on German Domestic Prices." *Journal of Industrial Economics* 35:61-70

Fienberg, R. M. (1989) "The Effects of Foreign Exchange Movements on U.S. Domestic Prices." *Review of Economics and Statistics* 71: 505-11

Fisher, E. (1989) "A Model of Exchange Rate Pass-Through." *Journal of International Economics* 26: 119-137.

Fraser, J., Taylor. M and Webster (1990) "Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations." *American Economic Review* 77:133-53

Freedman, C. (1995) "The Role of Monetary Conditions and the Monetary Conditions Index in the Conduct of Policy." *Speech published in the Bank of Canada Review* Autumn 1995

Frenkel, J. A. (1976) "Monetary Approach to the Exchange Rate: Doctrine Aspects and Empirical Evidence." *Scandinavian Journal of Economics* 78(2): 200-224

Friberg, R. (1998) "In Which Currency Should Exporters Set Their Prices?" *Journal of International Economics* 45(1): 59-76.

Friedman, M. (1953) "The Case of Flexible Exchange Rates: *In Friedman (ed) Essay in Positive Economics,* Chicago

Froot, K. A and K. Rogoff, (1995) " The Law of One Price over 700 years." *Working Paper* No. 5132. National Bureau of Economic research, Cambridge, MA.

Froot, K. A and P. P. Klemperer (1989) "Exchange Rate Pass-Through When Market Share Matters." *American Economic Review* 79: 637-54

Gagnon, E., Feenstra, R. and M. Knetter (1996) "Market Share and Exchange Rate Pass-Through in World Automobile Trade." *Journal of International economics* 40:187-207

Gibson, D. H. (1996) "International Finance, Exchange Rates and Financial Flows in the International System." Longman, London and New York, 1996.

Glesjer, H (1978) "A New Test for Heteroscedasticity," *Journal of American Statistical Association* 64: 316-323

Goldberg, K. (1995) "Product Differentiation and Oligopoly in International Markets: The Case of the U.S. Automobile Industry." *Econometica* 64:891-951

Goldberg, K. and M. M. Knetter (1997) "Goods Prices and Exchange Rates: What Have We Learned? *Journal of Economic Literature* 35(3): 1243-1272

Granger, C.W.J. (1969) "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods." *Econometrica* 37(3) (July): 9424-38.

Granger, C. W. J. (1986) "Developments in the Study of Co-integrated Economic Variables" *Oxford Bulletin of Economics and Statistics* 48

Grassman, S. (1973) "Exchange Rate Reserve and the Financial Structure of Foreign Trade." Hants, England: Saxon House.

Greene, W. H. (1997) "Econometric Analysis", 3rd edition, Prentice-Hall.

Gron, Anne and Swenson, Deborah (1996) "Exchange Rate Pass-Through and Imperfect Competition: The Effect of Local Production." *American Economic Review* 86:71-76

Government of Canada, (1972) "The Problem of the Appreciation of the Canadian Dollar." *Cabinet memorandum* 9: June.

Gujarati, N. G. (1995) " Basic Econometrics" Third Edition, McGraw-Hill International Edition

Helkie, W. and P. Hooper (1988) "An Empirical Analysis of the External Deficit." In Bryant, Holtham and Hooper (eds), *External Deficits and the Dollar: The Pit and the Pendulum*: 10-56

Helleiner, G. K. (1985) "Comment on Efficiency, Equity and Transfer Pricing in LDCs In *A. M. Rugman and L. Eden (eds), Multinational and Transfer Pricing*: 240-4

Heller, H. R. (1974) "International Monetary Economic" Prentice-Hall, Inc, New Jersey, 1974

Hendrik, S., Houthakker and S. P. Magee (1969) "Income and price Elasticity in World Trade." *Review of Economics and Statistics* 51: 111-25

Holmes, P. M. (1978) "Industrial Pricing Behavior and Devaluation." London

Holmes and Hutton (1992) "A New Test of Money- Income Causality." *Journal of Money, Credit and Banking* 24(3): Aug. 1992, 338-355

Hooper, P. and B. R. Lowrey (1979) "Impact of the Dollar Depreciation on the U.S. Price Level: An Analytical Survey of Empirical Estimates." *Staff Study 103 Washington: Board of Governors of the Federal Reserve System* (March)

Hsiao, C. (1978a) "Autoregressive Modeling of Canadian Money and Income Data." *Working Paper* no. 7812. Toronto: University of Toronto, Institute for Policy Analysis, August.

Hsiao, C. (1978b) "Autoregressive Modeling and Money-Income Causality Detection." *Technical Report* No.262. Palo Alto: Stanford University, Institute for Mathematical Studies in the Social Sciences, June.

Isard, P. (1987) "Lesson from Empirical Models of Exchange Rates." *IMF Staff Paper* 34: 1-28

Isard, P. (1977) " How far can we push the law of one price?" *American Economic Review* 67(5):942-48

Jarque, C. and A. Bera (1980) "Efficient Tests for Normality, Homoskedasticity, and Serial Independence of Regression Residuals," *Economics Letters,* 6: 255–259.

Johansen, Soren (1991) "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," *Econometrica,* 59: 1551–1580.

Johansen, Soren (1995) "Likelihood-based Inference in Cointegrated Vector Autoregressive Models", *Oxford University Press.*

Johansen, S. and K. Juselius (1990) "Maximum Likelihood Estimation and Inferences on Cointegration—with applications to the demand for money," *Oxford Bulletin of Economics and Statistics* 52: 169–210.

Johnston, Jack and John Enrico DiNardo (1997) "Econometric Methods", 4th edition, McGraw-Hill.

Kadiyali, V. (1997) "Exchange Rate Pass-through for Strategic Pricing and Advertising: An Empirical Analysis of the U.S. Photographic Film Industry" *Journal of International Economics* 43(3-4): 437-61.

Kasa, K. (1992) "Adjustment Costs and Pricing-to-Market: Theory and Evidence." *Journal of International economic* 32: 1-30

Kawai, M. (1984) "Exchange Rate-Price Causality in the Recent Floating Period." In *Floating Exchange Rates and the State of the World Trade and Payments*, edited by Bigman, D and T. Taya: 1984

Khosla, A. (1989) "Exchange Rate Pass-Through and Exporting Pricing Evidence from the Japanese Economy." *Journal of the Japanese and International Economics* 5: 41-59

Khosla, A. and J. Teranishi (1989) "Exchange Rate Pass-Through in Export Prices – An International comparison." *Hitotusbashi Journal of Economics* 30(1): 31-48

Kim, Y (1990) "Exchange Rates and Import Prices in the U.S.: A Varying Parameter Estimation of Exchange Rate Pass-Through." *Journal of Business and Economics Statistics* 8(3): 305-15

Kindleberger, C. P. (1973) "International Economics." 5th Edition: 327

Klein, M. and R. Murphy (1988) "Exchange Rate Interdependence and Import Price Pass-Through." *Mimeo.*, Clark University

Knetter, M. (1989) "Price Discrimination by U.S. and Germany Exporters." *American Economic review* 79(1): 198-210

Krenin, M. E. (1967) "Price Elasticity in International Trade." *Review of Economics and Statistics* 49: 510-16

Kreinin, M. E. (1977) "The Effect of Exchange Rate Changes on the Prices and Volume of Foreign Trade". *IMF Staff Paper* 24:297-329

Krugman, P. (1987) "Pricing to Market When the Exchange Rate Changes." *In Real-Financial Linkage Among Open Economies,* Eds.: Sven W. Arndt and J., David Richardson. Cambridge: MIT Press: 49-70

Krugman, P. and R. E. Baldwin (1987) "The Persistent of the U.S. Trade Deficit." *DPEA* 1: 1-43

Kugler, P. and Lenz, C. (1993) "Multivariate Cointegration Analysis and the Long Run Validity of PPP." *Journal of Economics and Statistics* LXXV: 1, 180-84

Lafleche, T. (1996) "The Impact of Exchange Rate Movements on Consumer Prices." *Bank Of Canada Review Article* Winter 1996

Lafrance, R and Norden, S. "Exchange Rate Fundamentals and the Canadian Dollar" *Bank of Canada*

Laidler, D. (1999) "The Exchange Rate Regime and Canada's Monetary Order." *Bank of Canada Working Paper* 99-7, March 1999

Lattimore, R. (1990) "Exchange Rate Changes and Competitiveness in Australia Manufacturing." *Working Paper* No. 48 (Bureau of Industrial Economics). Canberra

Lawson, R.W. (1970) "Exchange Rate Policy." *Bank of Canada, memorandum* 29 April

Lee, M. H. (1976) "Purchasing Power Parity, Business Economics and Finance." 1976

Letourneau, R. S., (1980) "Inflation: The Canadian Experience." A Report from the Conference Board of Canada, August 1980

MacDonarld, R. (1983) "Tests of Efficiency and the Impact of News in Three Foreign Exchange Markets: The Experiences of the 1920s." *Bulletin of economic Research* 35(2): 123-44

MacKinnon, J.G. (1991) "Critical Values for Cointegration Tests," *Chapter 13 in Long-run Economic Relationships:* Readings in Cointegration, edited by R.F.Engle and C.W.J. Granger, Oxford University Press.

Magee, S. P. (1973) "Currency Contracts, Pass through, and Devaluation." *Brookings Papers on Economic Activities* 1:303-323

Magee, S. P., (1974) "US Import Prices in the Currency-Contract Period." *Brooking Papers on Economic Activities* 1: 117-64

Mann, C. (1986) "Price, Profit Margins and Exchange rates." *Federal Reserve Bulletin* 72:366-379

Mann, C and P. Hooper (1989) " Exchange rate Pass-Through on the 1980s: The Case of US Imports of manufactures." *Brookings Paper on Economic Activities* 1: 297-337

Marquez, J. (1991) "The Dynamics of Uncertainty or the Uncertainty of Dynamics: Stochastic J-Curve." *Review of Economics and Statistics* LXXIII (1): 125-33

Marston, R. (1990) "Pricing to Market in Japanese Manufacturing." *Journal of International Economics* 29:217-36

Mastropasqua, C. and S. Vona (1988) "The US Current Account Imbalance and the Dollar: The Issue of the Exchange Rate Pass-Through." *Banca d'Italia*

McCallum, J. (1983) "Inflation and Social Consensus in the Seventies." *The Economic Journal* 93, No. 372: (Dec., 1983), pp. 784-805.

McConnell, Brue and Barbiero (1999) "Microeconomics." 8th Canadian Edition: McGraw-Hall. Ryerson.

McKinnon, R. I. (1979) "Money in International Exchange." Oxford University Press, Oxford

Melick, W. (1989) "The Stability of Exchange rate Pass-through in the 1980s." *Board of Government of the Federal Reserve System*

Menon, J. (1995a) "Exchange Rate Pass-Through" *Journal of economic Survey* 9(2): 197-231

Menon, J. (1995b) "Exchange Rate Pass-Through and Hysteresis on Import Prices: The Australian Experience." Berlin and Heidelberg: Spring-Verlag.

Menon, J. (1994) "The Theory of Exchange Rate and Traded Goods Prices on the Short Run." *Economia Internationale* XLVII: 55-68

Menon, J. (1993) "Exchange Rates, Import Prices and Macroeconomics." Economic papers 12: 37-48

Michael, P. Nobay, A. and D. Peel (1994) "PPP yet Again: Evidence from Spatially Separated Commodity Markets." *Journal of International Money and Finance* 13:637-57

Mirus, R. and B. Yeung (1987) "The Relevance of the Invoicing Currency in Intra-Firm Trade Transactions." *Journal of International Money and Finance* 6:449-64

Moffet, M. H. (1989) "The J-Curve Revisited: An Empirical Examination for the U.S." *Journal of International Money and Finance*

Moreno, R. (1989) "Exchange Rates and Trade Adjustment in Taiwan and Korea." *Federal Reserve Bank of San Francisco Economic Review* 2: 30-48

Muirhead, B. (1999) "Against the Odds: The Public Life and Times of Louis Rasminsky." Toronto: University of Toronto Press.

Mundel, R. (1968) "International Economics" (New York: Macmillan, 1968): Chs, 9, 11 and 15

Mussa, M (1974) "A monetary Approach to the Balance of Payments Analysis." *Journal of Money, Credit and Banking*: August 1974

Officer, L. (1976) "The PPP Theory of Exchange Rate: A Review Article." *IMF Staff Papers* 23: 1-60

Obstfeld, M. and Krugman, P. R. (1991) "International Economics, Theory and Policy." *2nd Edition*, 1991

Ohno, K. (1990) " Exchange Rate Fluctuations, Pass-Through and Market Share" *IMF Staff Papers* 37(2): 294-309

Patel, J. (1990) "PPP as a Long Run Relation." *Journal of Applied Econometrics*: 367-79

Pentti, J. and Kouri, K. (1984) "Monetary Policy, the Balance of Payments, and the Exchange Rate." New York University and Yale University.

Phillips, P.C.B. and P. Perron (1988) "Testing for a Unit Root in Time Series Regression," *Biometrika,* 75: 335–346.

Pierce, D. A and L. D. Haugh (1977) "Causality in Temporal System: Characterizations and Survey" *Journal of Econometrica* 5: 265-294

Pindyck, R. S. and D. L. Rubinfeld (1998) "conometric Models and Economic Forecasts" 4th Edition, McGraw-Hill.

Piggott, C. and V. Reinhart (1985) "The Strong Dollar and the U.S. Inflation." FRB of New York *Quarterly Review* 10: 23-29

Powell, J. (1999) "A History of Canadian Dollar, Bank of Canada." October 1999. http://www.bankofcanada.ca/en/dollar_book/dollar_book-e.pdf

Ramanathan, R (2002) "Introductory Econometrics with Application", Fifth Edition, Univ. of California-San Diego

Ramsey, J. B. (1969) "Tests for Specification Errors in Classical Linear Least Squares Regression Analysis," *Journal of the Royal Statistical Society*, Series B, 31, 350–371.

Rivera-Batiz, L F. and Rivera-Batiz, L. (1985) "International Finance and Open Economy Macroeconomics" 1985.

Rogoff, K. (1996) "The Purchase Power-Parity Puzzle?" *Journal of Economic Literature* 8(2): 341-51

Said, S.E. and D.A. Dickey (1984) "Testing for Unit Roots in Autoregressive Moving Average Models of Unknown Order," *Biometrika,* 71: 599–607.

Salvatore, D. (2001) "International Economics." Seventh edition, 2000

Salvatore, D. (1996) "Theory and problems of International economics." 4th edition, 1996, New York, McGraw-Hill

Samuelson, P. A. (1974 ) "Theoretical Notes on Trade Problems." *Review of Economics and Statistics* 46:145-454.

Sims C. A (1972) "Money, Income and Causality." *American Economic Review* 62(4): 540-52

Schembri, L. (1989) "Export Price and Exchange Rates: An Industry approach." *In Trade Policies for International Competitiveness*, edited by Freenstra, University of Chicago Press.

Spitaller. E. (1980) "Short Run Effects of Exchange Rate Changes on Terms of Trade and Trade Balance." *IMF Staff Paper* 27: 320-348

Taylor, M. P. (1988) "An Empirical Examination of Long Run PPP using Cointegration Technique." *Applied Economics* 20: 1369-82

Thiessen G. (2000) "The Conduct of Monetary Policy When You Live Next Door to a Large Neighbor" Remarks by Governor of the Bank of Canada to the Canadian Society of New York U.S.A.: *9 March 2000*

Venable (1990) "Microeconomic Implications of Exchange Rate Changes." *Oxford Review of Economic Policy* 6(3): 18-27

Wallich, H. C. "Floating as seen from the Central Bank." In *Floating Exchange Rates and the States of the World Trade and Payments,* edited by David Bigman and Teizo Taya: 1984, pp 33-42

Watts, G. S. (1993) "The Bank of Canada, Origins and Early History." Ottawa: Carleton University Press.

White, Halbert (1980) "A Heteroskedasticity-Consistent Covariance Matrix and a Direct Test for Heteroskedasticity," *Econometrica,* 48: 817–838

Woo, W. T. (1991) "Exchange Rate Changes and the Prices of Non-Food, Non-Fuel Items." *Brookings Papers on Economic Activity* 2: 511-30

Yang, Y. Y. (1991) "Structural Change in the US Import Prices of Manufactures." *Weltwirtschaftliches Archiv* 127(2):323-42