

Exchange Rate Pass-Through to Domestic Prices: The Case of Colombia

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Abstract

This study uses two different econometric frameworks to study exchange rate pass-through to import, producer and consumer prices in Colombia. Both frameworks are based on vector autoregressive (VAR) models, the first using an unrestricted VAR model, and the second using the Johansen framework of multivariate cointegration. Exchange rate pass-through is shown to be incomplete. Import prices, nevertheless, respond quickly to an exchange rate change, where some 80 percent of such a change is passed onto prices of imports within 12 months. The corresponding figure for producer prices is 28 percent and for consumer prices less than 15 percent, where for the latter the two different frameworks yield rather different results. We can, however, conclude that pass-through is modest for producer prices and very limited for consumer prices. An exchange rate shock does, therefore, only have little impact on consumer price inflation.

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Contents

1	Introduction
2	Exchange Rate Pass-Through
2.1	Definition
2.2	Review of the Literature
3	Data
3.1	The Data Set
3.2	The Different Exchange Rate Regimes in Colombia
4	Impulse-Response Functions within a VAR Framework
4.1	The VAR Framework
4.2	Estimation of the VAR
4.3	The Impulse-Response Functions
5	Impulse-Response Functions within a Johansen Framework
5.1	Likelihood Estimation and Results
5.2	The Impulse-Response Functions
6	Conclusion
	References

1 Introduction

The relatively large depreciation of the Colombian peso to the US dollar during 2002 has posed a challenge for Colombian monetary policy. From end-2001 to end-2002 the USD/COP rate of exchange depreciated by some 20.0 percent,¹ while consumer prices during the same period increased by 7.0 percent and producer prices by 9.3 percent. If not countered by the right monetary policies, such a rate of depreciation could easily transform into higher inflation.

Many monetary models of the exchange rate as well as of the balance of payments assume purchasing power parity and, thus, a one-to-one relationship between exchange rate changes and changes in domestic prices. Studies on exchange rate pass-through have almost unanimously rejected this assumption, particularly in the short run. If significant lags exist in the transmission of exchange rate changes to domestic prices, exchange-rate depreciation would only have limited impact on the rate of domestic inflation. A low degree of exchange rate pass-through would, furthermore make it possible for trade flows to remain relatively insensitive to changes in the exchange rate, despite demand being highly elastic. If prices respond sluggishly to changes in the exchange rate, and if trade flows respond slowly to the relative price change, then the overall balance-of-payments adjustment process could be severely held back.

The degree of exchange rate pass-through, consequently, have important implications for the design of monetary policy to counteract the inflationary as well as trade implications of an exchange rate shock. However, up to now the impact and dynamics of exchange rate changes on domestic prices in Colombia has not been fully quantified. Rincón (2000) is the only previous study on Colombian exchange rate pass-through. It reveals some important results regarding the long-term impact of an exchange rate change onto domestic prices, as well as some general short-term results. However, little is known

¹ This could be compared with a depreciation of 2.7 percent for the previous 12 month period, i.e. from end-2000 to end-2001.

about the dynamics of exchange rate pass-through in Colombia and its short-term properties.

This study aims to fill that gap. We will use two different econometric frameworks to study Colombian exchange rate pass-through. Both are based on vector autoregressive (VAR) models. The first uses an unrestricted VAR framework, and the second uses a framework of multivariate cointegration developed by Johansen (1988). In both cases, impulse-response functions are used to analyse the dynamics of the exchange rate pass-through. We will use 20 years of monthly data from January 1983 up until October 2002. We will, furthermore, use the nominal USD/COP rate² of exchange to study its effect on the different stages of the distribution chain, i.e. on import, producer and consumer prices. In the Johansen analysis, we will also include the output gap in the model, which is a requirement to obtain valid cointegrating relationships.

Exchange rate pass-through in Colombia is shown to be incomplete, which is in line with most other studies. Import prices respond relatively quickly to an exchange rate change. After three months, 48 percent of a change in the exchange rate has been passed onto import prices, and after 12 months, the pass-through is as much as 80 percent. Producer prices respond much more sluggishly, with only around 8 percent pass-through after three months. However, after one year the exchange rate pass-through to producer prices reaches 28 percent. The response of consumer prices to exchange rate changes is relatively limited. The two studies yield somewhat different results. The study using an unrestricted VAR framework yields a pass-through of 8 percent after 12 months, while the study using the Johansen framework yields a pass-through of 15 percent. The short-term response (after three months) of the consumer price index to an exchange rate change is, nevertheless, very limited. It is less than 4 percent in both the studies.

² The USD/COP rate of exchange is in fact the exchange rate expressed as Colombian pesos per US dollar, in accordance with classical exchange rate terminology. We will stick to this terminology throughout this paper, even if it is all but logical.

The paper is organised as follows: Exchange rate pass-through is defined and the theoretical concept discussed in chapter 2. This chapter also includes a review of the relevant empirical literature. Chapter 3 continues by introducing the data set. In chapter 4 the analysis and the results of the study using an unrestricted VAR framework are presented. Chapter 5 presents the analysis and results of the study using the Johansen framework, and Chapter 6 concludes the paper.

2 Exchange Rate Pass-Through

Empirical studies have shown that domestic prices do not respond one-for-one to an exchange rate change, particularly not in the short run. The degree of exchange rate pass-through to domestic prices, then, becomes a very important variable when designing monetary policies. The concept of exchange rate pass-through is defined in section 2.1, and section 2.2 continues by reviewing the empirical literature on the subject.

2.1 Definition

“The textbook definition of exchange rate pass-through is the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries”.³ Changes in import prices are, nevertheless, to some extent passed on to producer and consumer prices. We are, therefore, in this paper using a broader definition of exchange rate pass-through, which is seen as the change in domestic prices that can be attributed to a prior change in the nominal exchange rate.⁴

Balance-of-payments models normally assume a one-for-one response of import prices to exchange rates, which is known as *complete* exchange rate pass-through. For this to be the case, two conditions need to be fulfilled. First, mark-ups of price over cost have to be constant, and second, marginal costs have to be constant. If these conditions are fulfilled, the response of the trade balance to exchange rate changes is driven by the elasticity of demand for imports in the respective countries.⁵

Exchange rate pass-through is, however, in reality far from complete. According to Goldberg and Knetter (1997), only around 60 percent of exchange rate changes are

³ Goldberg and Knetter (1997), p. 1248.

⁴ See Kahn (1987), Menon (1995a), and Goldberg and Knetter (1997) for an extensive discussion on exchange rate pass-through.

⁵ Textbook models normally assume perfectly competitive industries and mark-ups of price over cost to be constant at zero. See Goldberg and Knetter (1997), p. 1248.

passed on to import prices in the United States,⁶ even if this figure varies significantly across industries. The main explanation for this phenomenon is that many importing and exporting firms choose to hold their prices constant and simply reduce or increase the mark-up on prices, when the exchange rate is changing. Such behaviour is referred to as *pricing-to-market*.⁷ Many firms might, consequently, choose to make temporary losses on their revenue not to lose market share to competition. Empirical studies have found the extent of pricing-to-market to be positively correlated with market concentration. Pricing-to-market, thus, tend to be more present within competitive industries.⁸

2.2 Review of the Literature

A literature search on exchange rate pass-through quickly reveals that the majority of the studies made in the area are industry or product specific studies.⁹ These studies analyse the pass-through to import prices of different products or industries on the micro level rather than focusing on the effects of aggregate price measures. The study undertaken in this paper does, however, look at the economy at the macro level, and we will, therefore, concentrate this literature survey mainly on such aggregate studies.

Menon (1995a) is probably the most comprehensive survey of the literature on exchange rate pass-through up to date. He presents an overview of 43 empirical studies on industrialised economies, of which the most often studied is the United States. The majority of these studies conclude that exchange rate pass-through is incomplete, indeed. The degree of pass-through does, however, vary significantly across different countries. The main factors that influence the degree of pass-through across countries is the size and the openness of the individual economies.

⁶ Pass-through estimates of many studies seem to be centered around this figure. See Goldberg and Knetter (1997), p. 1250.

⁷ See Krugman (1987), and Dornbusch (1987).

⁸ See Goldberg and Knetter (1997), p. 1252ff.

⁹ Examples of recent such studies include Bernhofen and Xu (2000), Kardasz and Stollery (2001), Olivei (2002), and Takagi and Yoshida (2001).

Menon (1995a), furthermore, reports that pass-through relationships have remained largely stable over time.¹⁰ Different results for a country stem primarily from the use of different methodologies, model specifications and variable selections rather than from different time periods studied. In particular there is an aggregation problem, whereby the choice of price aggregate has a potentially large impact on the result.¹¹ Some studies have also found pass-through to be asymmetric, which implies that the rate of pass-through is different during exchange rate appreciations and depreciations.¹²

All but one of the studies reviewed by Menon (1995a) use an OLS estimation technique. This does not properly account for the time-series properties of the data, particularly the non-stationarity. Kim (1991) is the only study to apply a vector autoregressive (VAR) framework. The majority of the more recent studies use VAR frameworks to investigate exchange rate pass-through.

McCarthy (2000) presents a comprehensive study of exchange rate pass-through on the aggregate level for a number of industrialised countries. He estimates a VAR model using import, producer and consumer-price data from 1976 up until 1998. In most of the countries analysed, the exchange rate pass-through to consumer prices is found to be modest. The rate of pass-through is, furthermore, shown to be positively correlated with the openness of the country and with the persistence of and exchange rate change, and negatively correlated with the volatility of the exchange rate.

¹⁰ See also Parsley (1993). Some studies have, nevertheless, challenged this result. See, for example, Taylor (2000), and Gagnon and Ihrig (2001).

¹¹ Not only is there a large difference between the results using, for example, a producer price index and a consumer price index, which is shown in this study, but different definitions of, for example, a consumer price index might yield different results. This implies that caution needs to be applied when comparing the results of different studies from different countries.

¹² Such studies include Mann (1986), Kreinin, Martin and Sheehey (1987), and Marston (1990). However, some other studies have found no evidence for such an asymmetry, including Lawrence (1990) and Athukorala (1991).

Kim (1998) investigates exchange rate pass-through in the United States using a framework of multivariate cointegration. This study relates changes in producer prices to changes in the trade weighted nominal effective exchange rate, money supply, aggregate income and interest rates. The exchange rate is found to contribute significantly to producer prices.

Goldfajn and Werlang (2000) present a study of 71 countries, where exchange rate pass-through onto consumer prices is investigated using panel estimation methods on data from 1980 up until 1998. Both developed and emerging market economies are included. They report that the pass-through effects on consumer prices increase over time and reach a maximum after 12 months. The degree of pass-through is, furthermore, found to be substantially higher in emerging market economies than in developed economies.

Rincón (2000) is the only aggregate study made on exchange rate pass-through in Colombia. This study uses the Johansen framework to estimate the pass-through effect. It uses monthly data for the period 1980 to 1998. Exchange rate pass-through is found to be incomplete. The estimated long-term elasticities of import and export prices to a change in the exchange rate are 0.84 and 0.61 respectively. The direct long-term effect of the exchange rate on the consumer prices is found to be 0.48.

Feinberg (2000) studies exchange rate pass-through in Colombia, Korea and Morocco using industry-level data and an OLS regression technique. The sample for Colombia consists of pooled annual data for 25 industries over eight years, 1980 to 1987. The study reports a long-term effect of the real effective exchange rate on pooled wage adjusted producer prices to be 0.51. The exchange rate pass-through is, thus, found to be incomplete. However, the price and exchange rate indices used make it difficult to compare the results with other studies.¹³ The time period studied is, furthermore, too short to draw any definite conclusions of the long-term relationship.

¹³ The study uses the real effective exchange rate, real gross domestic product, and industry specific producer price indices that have been deflated by an economy-wide wage index. The results of the study are, therefore, not directly comparable to the results of most other studies that use the nominal exchange rate together with the (nominal) producer price index.

We will in this paper use two different econometric frameworks, which both are based on VAR models. First we use an unrestricted VAR framework, in line with McCarty (2000). This has the advantage of being simple by only including the exchange rate and the price indices. We then continue by using a framework of multivariate cointegration in line with Kim (1998) and many other recent studies.¹⁴

¹⁴ Such studies include, for example, Hüfner and Schröder (2002), Kenny and McGettigan (1998), Menon (1995b), and Murgasova (1996).

3 Data

This chapter presents the data set used in the econometric analysis in the following two chapters. The data set is defined in section 3.1. Section 3.2 discusses the different exchange rate regimes in place in Colombia. This is relevant when determining the causality between the exchange rate and the domestic prices.

3.1 The Data Set

For the empirical analysis we use 20 years of monthly data from January 1983 until October 2002.¹⁵ We use the USD/COP rate of exchange to represent the exchange rate.¹⁶ We, furthermore, include all stages of the distribution chain, i.e. import prices, producer prices and consumer prices. All the prices are in the form of price indices.¹⁷ In the cointegration analysis in chapter 5, we also include data for the output gap, which is computed as the difference between actual industrial production and potential output. The latter is constructed using a Hodrick-Prescott filter. The data source is Banco de la República for all the data. All the data, apart from the exchange rate data, is, furthermore, seasonally adjusted, and all the time series are in logarithmic form, with the exception of the output gap.

¹⁵ Apart from data for industrial output, which only existed up until December 2001 when the analysis was conducted.

¹⁶ A trade-weighted nominal effective exchange rate index was initially used in the analysis. However, the estimation residuals never passed the test for normality. The time series for the USD/COP exchange rate did not experience these problems, and was, therefore, used instead. United States is by far Colombia's largest trading partner (with some 49.1 percent of exports and 35.9 percent of imports in 1999) followed by Venezuela at a distant second place (8.0 percent of exports and 8.1 percent of imports). A large majority of exports and imports are, furthermore, priced in US dollars, so the USD/COP exchange rate may, in fact, be more appropriate than a trade weighted nominal effective exchange rate index. The measurement of the exchange rate can have a large impact on the result of pass-through studies, which has attracted some attention in the literature. See, for example, Athukorala and Menon (1994), Citrin (1989), Feinberg (1991), and Woo (1984).

¹⁷ The choice of price indices can, however, have a large impact on the results. The bias introduced into estimates of pass-through as a result of measurement errors contained in price proxies is highlighted by Alterman (1991), who compares the relatively different results obtained using an import price index versus import unit values.

3.2 The Different Exchange Rate Regimes in Colombia

From 1967 and up until 1991, the exchange rate regime in Colombia was defined by a crawling peg. The Colombian peso was pegged to the U.S. dollar at a pre-specified exchange rate and was not allowed to depart significantly from this rate. This exchange rate was, furthermore, devalued daily at a pre-determined and continuous devaluation rate. The exchange rate regime was combined with a system of thorough capital controls, where all foreign exchange transactions had to be made through the Banco de la República.¹⁸

The crawling peg regime was abolished in June 1991, following a sharp fall in international coffee prices and a deterioration in the trade balance. A market for foreign exchange was created, where the exchange rate was freely determined.¹⁹ However, the Banco de la República continued to intervene in the market, and in practice the new exchange rate regime was a managed floating regime with many similarities to a crawling exchange rate band.

In January 1994, the central bank introduced an official crawling band regime. This was to regain control over monetary variables, after a period of very low real interest rates in combination with very large capital inflows. The exchange rate was allowed to fluctuate around a pre-determined central rate, which initially was to be continuously devalued at an annual rate of 11 percent. The actual exchange rate could depart with as much as 7 percent from the central rate. In many ways, the regime resembled a managed float, since the limits of the band were shifted several times, and since the band was relatively wide.²⁰

¹⁸ For a thorough discussion on the Colombian exchange rate regimes, see Villar and Rincón (2000), as well as Cárdenas (1997). The discussion here draws heavily from Villar and Rincón (2000), as well as from Rowland (2003).

¹⁹ The market traded Exchange Rate Certificates (Certificados de Cambio) which were US dollar denominated interest bearing papers issued by the Banco de la República. See Villar and Rincón (2000), pp 27ff.

²⁰ Villar and Rincón (2000), p. 30.

In September 1999, the exchange rate band was dismantled, and the exchange rate was allowed to float freely. This followed a period of economic difficulties. Colombia was in a recession, the government was running a large fiscal deficit, and the credibility of the currency band system had rapidly been deteriorating. The floating regime, which has been in place since then, is close to a free float. The central bank can only intervene to reduce short-term exchange rate volatility, and has not done so until 2002.²¹

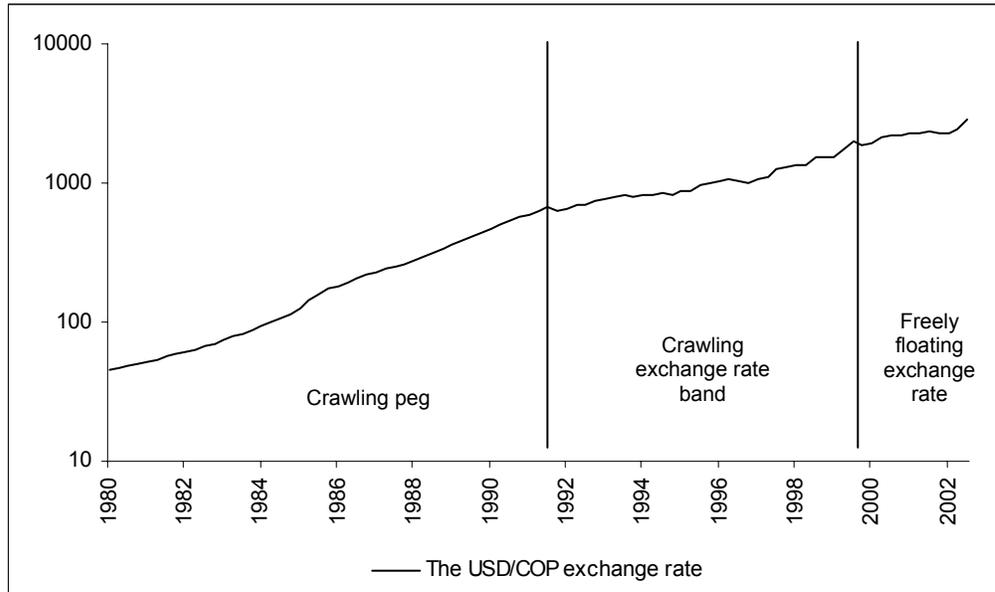
Figure 3.1 shows the exchange rate development since 1970, and figure 3.2 shows the exchange rate variability. It is apparent from figure 3.1 that the exchange rate left its path of a long-term stable depreciation rate in 1991, when the crawling peg was abandoned. As expected, the short-term variability of the exchange rate also increased significantly, as shown by figure 3.2. However, there was no significant change in exchange rate variability between the crawling band regime and the floating regime, which was introduced in 1999. If we calculate the average absolute weekly change for the periods January 1994 to September 1999 and October 1999 to August 2002 we receive values of 0.72 percent and 0.68 percent respectively.

We can, consequently, conclude that the time series data we are studying includes at least one significant structural break, generated by the abolishment of the crawling-band regime in June 1991. In the case of a pegged exchange rate, the causality between the nominal exchange rate and the price level should run from the former to the latter, while in the case of a freely floating exchange rate, the causality should run in the opposite direction.²² A change in the exchange rate regime might thus influence the exchange rate pass-through in the economy. However, the time series for the floating rate period in Colombia are not long enough to investigate this.

²¹ The central bank can only intervene if the average exchange rate of a given day deviates more than 4 percent from its 20-day moving average.

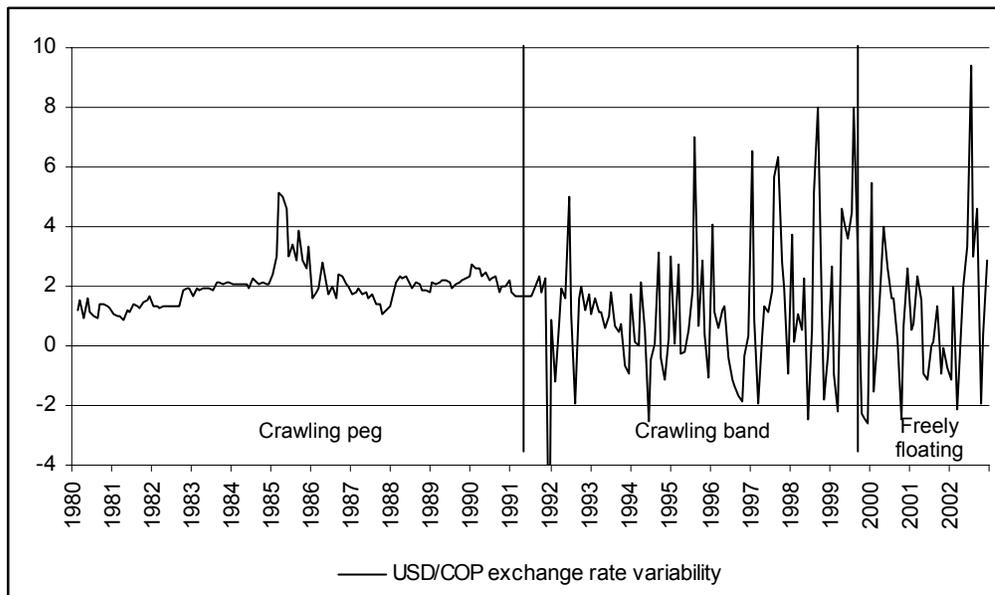
²² Empirical studies have, nevertheless, shown that this is not always the case. See Rincón (2000) for a discussion.

Figure 3.1. The USD/COP exchange rate under the different regimes (logarithmic scale)



Source: Banco de la República.

Figure 3.2. Short-term variability of the USD/COP exchange rate, expressed as percentage change from previous quarter



Source: Banco de la República.

The assumption that causality runs from prices into the exchange rate under a floating exchange rate regime can, nevertheless, be discussed. A floating exchange rate is, in many cases, determined by other variables rather than by the relative price levels.²³ This is particularly relevant for emerging market economies, where contagion and reoccurring crises have played a major part during recent years. This has generated exchange rate shocks, which have in various degrees been passed onto the domestic price levels.

We will in this paper study the pass-through for the whole 20-year period from 1983 up until 2002. We will, furthermore, in section 5.2 test for exogeneity of the exchange rate in relation to the price indices. These tests are passed, indicating that we can assume that causality runs from the exchange rate into prices, which is important when determining the impulse-response functions.

²³ A classical example are the large and persistent deviations of the USD/DEM exchange rate during the 1980s and 1990s. See, for example, Isard (1995) for a discussion.

4 Impulse-Response Functions within a VAR Framework

To investigate the pass-through of exchange rate fluctuations to domestic prices, we will use two different econometric frameworks, which both are based on vector autoregressive (VAR) models. In this chapter we use an unrestricted VAR framework, which is in line with McCarthy (2000). In the next chapter we will carry out the analysis using a framework of multivariate cointegration.

The unrestricted VAR model is introduced in section 4.1. Section 4.2 continues with the estimation of the VAR, and in section 4.3, the impulse-response functions are studied.

4.1 The VAR Framework

We will in this chapter estimate an unrestricted VAR model, and study the impulse response functions generated from this model. The unrestricted VAR is defined by the following four equations:

$$\Delta s_t = \sum_{i=1}^k \gamma_{11}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{12}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{13}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{14}^i \Delta cpi_{t-i} + \varepsilon_{1t} \quad (4.1)$$

$$\Delta imp_t = \sum_{i=1}^k \gamma_{21}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{22}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{23}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{24}^i \Delta cpi_{t-i} + \varepsilon_{2t} \quad (4.2)$$

$$\Delta ppi_t = \sum_{i=1}^k \gamma_{31}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{32}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{33}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{34}^i \Delta cpi_{t-i} + \varepsilon_{3t} \quad (4.3)$$

$$\Delta cpi_t = \sum_{i=1}^k \gamma_{41}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{42}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{43}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{44}^i \Delta cpi_{t-i} + \varepsilon_{4t} \quad (4.4)$$

where γ_{nm}^i are parameters to be estimated, k is the maximum distributed lag length, Δ is the difference operator and ε_{nt} are independent and identically distributed error terms. The time series data used for the estimations consists of the exchange rate, s , the import price index, imp , the producer price index, ppi , and the consumer price index, cpi .

4.2 Estimation of the VAR

The unrestricted VAR model defined by equation (4.1) to (4.4) is estimated using monthly data from January 1983 to October 2002. The maximum lag length, k , is chosen to be long enough for the error terms to be normally distributed and not serially correlated. As shown by Table 4.1, the residual tests for the model are all passed for a maximum lag length of 12.

Table 4.1. Residual tests of the unrestricted VAR model
(using monthly data from Jan 1983 to Oct 2002, and a maximum lag length $k = 12$)

Test	Test Statistic	P-value
<i>Multivariate Normality</i>		
Lütkepohl test	$\chi^2(8) = 6.34$	0.609
<i>Autocorrelation</i>		
Portmanteau test	Port(60) = 770.4	0.468
LM test	LM(60) = 20.46	0.434
<i>Unit Roots</i>		
ADF test residual ε_1	ADF(0) = -14.47	
ADF test residual ε_2	ADF(0) = -15.86	
ADF test residual ε_3	ADF(0) = -14.73	
ADF test residual ε_4	ADF(0) = -14.64	

4.3 The Impulse-Response Functions

In order to determine impulse-response functions, the variables need to be given a plausible ordering. We use the following ordering for the impulse-response analysis:

$$s \rightarrow imp \rightarrow ppi \rightarrow cpi$$

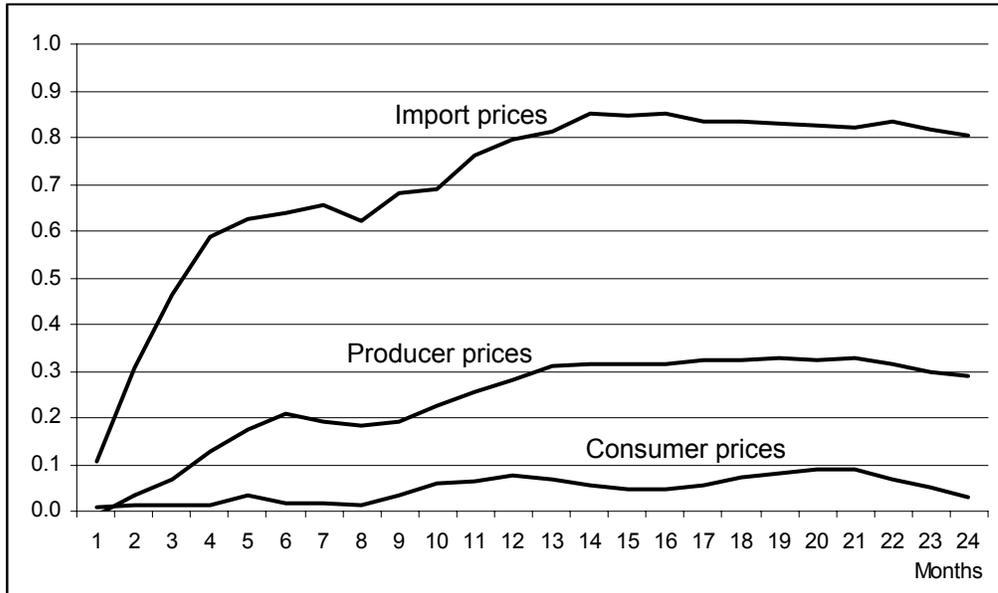
The exchange rate s is assumed to be exogenous. This assumption will be tested in the cointegration analysis in the next chapter, and it does, indeed, pass these tests. Table 4.2 displays the responses of domestic prices to a one-percent shock in the USD/COP exchange after 3, 6, 12 and 24 months. Figure 4.1 graphs the impulse-responses.

It is apparent that import prices respond rapidly to an exchange rate shock. After three months, 47 percent of an exchange rate change has been passed onto import prices, and after 12 months, 80 percent has been passed on. Producer prices respond considerably less. After 12 months only 28 percent of an exchange rate change has been passed onto producer prices. The response of consumer prices is only marginal. Less than ten percent of an exchange rate shock is passed onto consumer prices in the long run. In the short run, consumer prices hardly respond to exchange rate changes at all.

Table 4.2. Effects of domestic price indices to a one-percent exchange rate shock

	After 3 months	After 6 months	After 12 months	After 24 months
Import prices	0.47	0.64	0.80	0.80
Producer prices	0.07	0.21	0.28	0.29
Consumer prices	0.01	0.02	0.08	0.03

Figure 4.1. Response of domestic price indices to a one-percent exchange rate shock



5 Impulse-Response Functions within a Johansen Framework

In this chapter we are using the Johansen framework of multivariate cointegration to investigate the exchange rate pass-through. This is in line with a number of earlier studies.²⁴ In section 5.1 the estimation results are reported, and section 5.2 studies the impulse-response functions.

5.1 Likelihood Estimation and Results

The Johansen estimation test procedure used here, is a method for estimating the cointegrating relationships that exist between a set of variables as well as testing these relationships. The framework was originally developed by Johansen (1988)²⁵ and has since then been widely used and documented.²⁶

We are using three separate models to investigate exchange rate pass-through. These are defined as (s, imp) , (s, ppi, gap) , and (s, cpi, gap) , where s as before is the nominal USD/COP rate of exchange, and imp , ppi and cpi are the import price, producer price and consumer price indices. The output gap, gap , is defined as the difference between actual industrial production and potential output. From the unit root tests in table 5.1, we conclude that all the data is integrated of order two, $I(2)$, apart from the output gap, which is stationary.

Several alternative models were tested during the analysis. Many other studies using a multivariate cointegration framework use a model specification on the form $(s, imp, ppi, cpi, gap, i)$, where i is nominal interest rate. Such a specification was tried on the Colombian data, but the normality test of the residuals was rejected, and the test results were, therefore, not valid. A specification on the form (s, imp, exp^*) , where exp^* is the

²⁴ See, for example, Hüfner and Schröder (2002), Kenny and McGettigan (1998), Kim (1998), Menon (1995b), Murgasova (1996), and Rincón (2000).

²⁵ See also Johansen (1990, 1991, 1995).

²⁶ See, for example, Enders (1995).

U.S. export price index, was also tested. This intuitive form states that there should be purchasing power parity among Colombian import prices and U.S. export prices. A valid cointegrating relationship was, however, not found. This can possibly be explained by the fact that the basket defining the Colombian import price index and the basket defining the U.S. export price index are very different.

Table 5.1. Unit root tests for the time series

Variable	Level	First Difference	Second Difference
<i>s</i>	ADF(12) = -2.42	ADF(12) = -2.47	ADF(12) = -5.31
<i>imp</i>	ADF(10) = -2.20	ADF(10) = -2.25	ADF(10) = -4.33
<i>ppi</i>	ADF(8) = -3.02	ADF(8) = -1.48	ADF(8) = -6.98
<i>cpi</i>	ADF(8) = -2.40	ADF(8) = -1.18	ADF(8) = -5.28
<i>gap</i>	ADF(6) = -4.70	ADF(6) = -4.66	ADF(6) = -14.69

Note: The Augmented Dickey-Fuller test is used to test for unit roots. The value in parentheses is the order of the lag used, which is decided by using the Schwartz information criteria. The null hypothesis in each case is that the variable is integrated of order one and, thereby, non-stationary. The 5 percent rejection region for non-stationarity for the Dickey-Fuller statistic is $ADF < -2.89$, and the 1 percent rejection region is $ADF < -3.46$, according to Fuller (1976).

Nevertheless, the three models (*s, imp*), (*s, ppi, gap*), and (*s, cpi, gap*) all yielded valid cointegrating relationships, even if the consumer price index presented some problems. If the set of variables (*s, cpi, gap*) were estimated for the full period January 1983 to December 2001, a valid cointegrating relationship was rejected. However, if the data period was truncated to September 1985 to December 2001, the estimation results indicated a valid cointegrating vector.

Table 5.2. Estimation of the model using import prices
(using monthly data from Jan 1983 to Oct 2002)

Model	VEC(12): Drift	
Variables	(s, imp)	
Information criteria	Akaike: -12.2 Schwartz: -11.4	
Unrestricted cointegrating vector		
$\beta^T = (\beta_{11} \ \beta_{12})$	$\beta^T = (1.000 \ -1.292)$	
Restriction test		
$(\alpha_{11} = 0)$	$\chi^2(1) = 0.34$	P-value: 0.56
Restricted cointegrating vector		
$\beta^T = (\beta_{11} \ \beta_{12})$	$\beta^T = (1.000 \ -1.242)$	
Speed of adjustment		
$\alpha^T = (\alpha_{11} \ \alpha_{12})$	$\alpha^T = (-0.000 \ -0.001)$	
Multivariate normality		
Lütkepohl test	$\chi^2(4) = 7.52$	P-value: 0.111
Autocorrelation		
Portmanteau test	Port(60) = 220.4	P-value: 0.078
LM test	LM(60) = 5.81	P-value: 0.214

Table 5.3. Estimation of the model using producer prices (and output gap)
(using monthly data from Jan 1983 to Dec 2001)

Model	VEC(14): Drift	
Variables	(s, ppi, gap)	
Information criteria	Akaike: -15.9 Schwartz: -13.7	
Unrestricted cointegrating vector		
$\beta^T = (\beta_{11} \ \beta_{12} \ \beta_{13})$	$\beta^T = (1.000 \ -0.686 \ -85.92)$	
Restriction test		
$(\alpha_{11} = 0)$	$\chi^2(1) = 0.35$	P-value: 0.85
Restricted cointegrating vector		
$\beta^T = (\beta_{11} \ \beta_{12} \ \beta_{13})$	$\beta^T = (1.000 \ -0.661 \ -109.33)$	
Speed of adjustment		
$\alpha^T = (\alpha_{11} \ \alpha_{12} \ \alpha_{13})$	$\alpha^T = (-0.000 \ 0.000 \ -0.010)$	
Multivariate normality		
Lütkepohl test	$\chi^2(6) = 11.87$	P-value: 0.065
Autocorrelation		
Portmanteau test	Port(60) = 457.5	P-value: 0.069
LM test	LM(60) = 9.01	P-value: 0.467

Table 5.4. Estimation of the model using consumer prices (and output gap)
(using monthly data from Sep 1985 to Dec 2001)

Model	VEC(14): Drift	
Variables	(s, cpi, gap)	
Information criteria	Akaike: -16.4 Schwartz: -14.1	
Unrestricted cointegrating vector		
$\beta^T = (\beta_{11} \ \beta_{12} \ \beta_{13})$	$\beta^T = (1.000 \ -0.560 \ 53.76)$	
Restriction test		
$(\alpha_{11} = 0)$	$\chi^2(1) = 0.59$	P-value: 0.44
Restricted cointegrating vector		
$\beta^T = (\beta_{11} \ \beta_{12} \ \beta_{13})$	$\beta^T = (1.000 \ -0.583 \ 73.49)$	
Speed of adjustment		
$\alpha^T = (\alpha_{11} \ \alpha_{12} \ \alpha_{13})$	$\alpha^T = (-0.000 \ 0.000 \ -0.009)$	
Multivariate normality		
Lütkepohl test	$\chi^2(4) = 10.19$	P-value: 0.117
Autocorrelation		
Portmanteau test	Port(60) = 458.9	P-value: 0.063
LM test	LM(60) = 11.45	P-value: 0.246

The results of the estimation procedure are presented in table 5.2, 5.3 and 5.4. The maximum distributed lag length is chosen using information criteria. Likelihood ratio tests lead us to assume one cointegrating vector in all the cases. We also impose the restriction that the exchange rate is exogenous, and that changes in the exchange rate cause changes in domestic prices, and not the other way around. This restriction is passed by validity tests in all the models.

The models estimated allow us to determine the input-response functions and, thereby, also the pass-through. The estimated long-run cointegrating relationships do, however, in this case not make much sense. The relationships estimated here can be stated as

$$s = a_{11} + a_{12} \textit{imp} \tag{5.1}$$

$$s = a_{21} + a_{22} \textit{ppi} + a_{23} \textit{gap} \tag{5.2}$$

$$s = a_{31} + a_{32} \textit{cpi} + a_{33} \textit{gap} \tag{5.3}$$

where a_{11} , a_{12} , a_{21} , a_{22} , a_{23} , a_{31} , a_{32} and a_{33} are parameters to be estimated. These equations do, however, not make much theoretical sense, since there are other variables influencing the long-term relationships between prices and the exchange rate. The parameter estimates do, therefore, not tell us very much. The derived impulse-response functions are, nevertheless, valid.

5.2 The Impulse-Response Functions

The variables are given the same order as in the previous chapter, i.e.

$$s \rightarrow imp \rightarrow ppi \rightarrow cpi$$

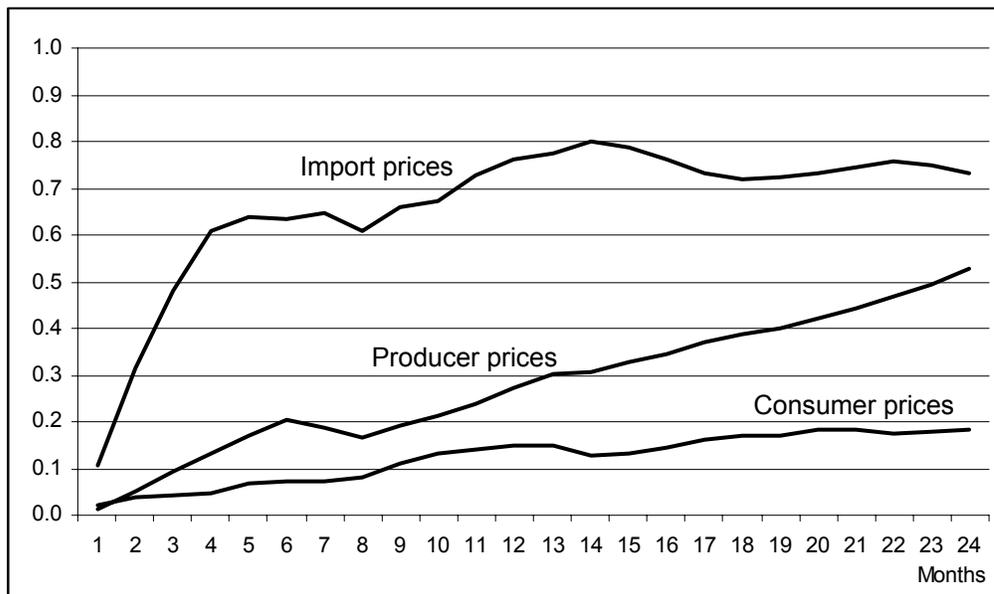
We can assume the exchange rate to be exogenous, since this restriction was passed by validity tests in all the models. Table 5.5 summarises the responses of domestic prices to a one-percent shock in the USD/COP exchange after 3, 6, 12 and 24 months. Figure 5.1 graphs the impulse-responses.

Table 5.5. Effects of domestic price indices to a one-percent exchange rate shock

	After 3 months	After 6 months	After 12 months	After 24 months
Import prices	0.48	0.63	0.76	0.73
Producer prices	0.09	0.20	0.27	0.53
Consumer prices	0.04	0.07	0.15	0.18

The results here are relatively similar to those from the unrestricted VAR model, with a few exceptions. Consumer prices here react stronger to an exchange rate change than in the unrestricted VAR model. After 24 months 18 percent of an exchange rate chock has been passed onto consumer prices, while this figure was only 3 percent in the unrestricted VAR model. Producer prices also respond more to an exchange rate change, particularly in the longer term. After 24 months, 53 percent of an exchange rate chock has been passed onto producer prices, which the corresponding figure in the unrestricted VAR model was only 29 percent.

Figure 5.1. Response of domestic price indices to a one-percent exchange rate shock



If the three models (s, imp) , (s, ppi, gap) , and (s, cpi, gap) are estimated using an unrestricted VAR framework, the results more resemble the results obtained here with the Johansen model than the results obtained in the previous chapter. The model specification seems to matter more in this case, than the exact econometric framework used. This is also in line with other studies, which have reported significant differences in the results when different models are used. Menon (1995a) compares the results of seven studies of aggregate exchange rate pass-through on import prices in the US economy.²⁷ He concludes that “given that there is little difference between these studies in terms of commodity or time coverage, the diversity in pass-through estimates would seem to stem primarily from differences in methodology, model specification and variable construction”.²⁸

²⁷ The estimates of exchange rate pass-through to import prices range from 48.7 percent to 91 percent. The time period studied runs from around 1970 to around 1987 for all the studies.

²⁸ Menon (1995a), p. 224f.

6 Conclusion

This study has analysed the exchange rate pass-through to domestic prices in Colombia. The degree of exchange rate pass-through is a very important variable when designing monetary policies, particularly in response to an exchange rate shock, like the large real depreciation of the USD/COP exchange rate during 2002.

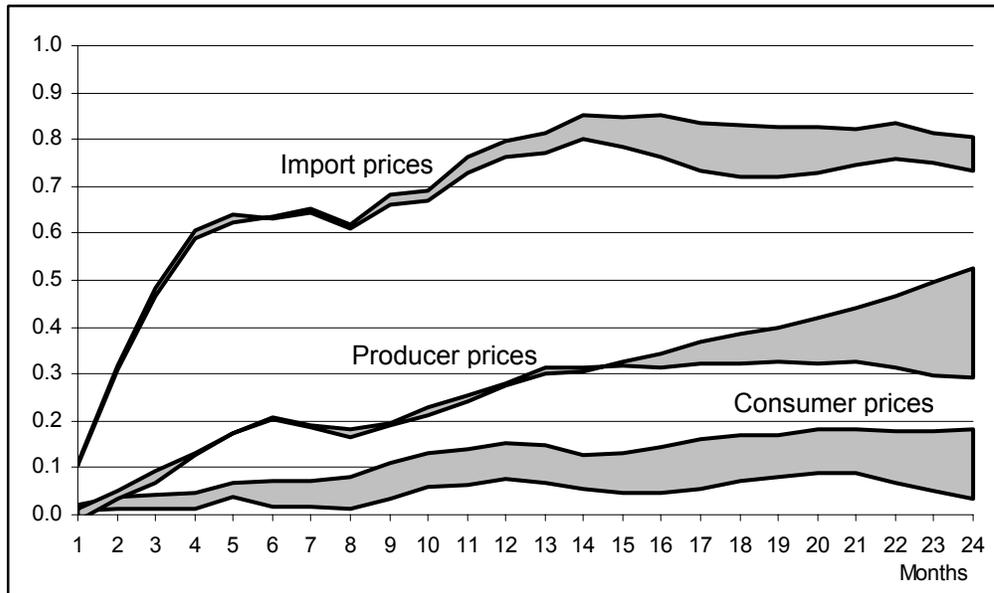
The study used two different frameworks, both based on VAR models. The first uses an unrestricted VAR framework, and the second a framework based on multivariate cointegration in accordance with Johansen (1988). Impulse-response functions are used in both the frameworks to study the dynamics of exchange rate pass-through.

The results of the study are summarised in Figure 6.1 and Table 6.1. In line with most empirical studies of exchange rate pass-through, this study concludes that pass-through in Colombia is incomplete. Import prices respond swiftly to an exchange rate change, with pass-through coefficients of 0.48 after three months and 0.80 after one year. Producer prices respond more sluggishly, with a pass-through coefficient of 0.28 after one year. When it comes to consumer prices, the two econometric frameworks used produce relatively different results. The unrestricted VAR framework yields a pass-through coefficient of 0.08 after one year, while the Johansen framework yields a coefficient of 0.15. The two frameworks, furthermore, produce very different results on the 24-month horizon, particularly for producer and consumer prices. The fact that the two econometric frameworks used produce different results is in line with findings of other studies.

A further point that should be made, is that the confidence intervals for the estimates have not been estimated.²⁹ These are potentially large, and the results should, therefore, be treated as approximations.

²⁹ Eviews, which was the software package used for this study, does not allow us to estimate the confidence intervals.

Figure 6.1. Response of domestic price indices to a one-percent exchange rate shock



Note: Grey areas indicate the difference between the estimates of the unrestricted VAR framework and the Johansen framework.

Table 6.1. Effects of domestic price indices to a one-percent exchange rate shock

	Response to an exchange rate shock			
	Econometric framework: Unrestricted VAR/Johansen			
	After 3M	After 6M	After 12M	After 24M
Import prices	0.47 / 0.48	0.64 / 0.63	0.80 / 0.76	<i>0.80 / 0.73</i>
Producer prices	0.07 / 0.09	0.21 / 0.20	0.28 / 0.27	<i>0.29 / 0.53</i>
Consumer prices	0.01 / 0.04	0.07 / 0.07	<i>0.08 / 0.15</i>	<i>0.03 / 0.18</i>

Note: Figures written in italic indicates that the difference between the estimates of the unrestricted VAR framework and the Johansen framework is larger than 0.05.

We can, consequently, conclude that even if import prices respond rapidly to an exchange rate change, with as much as 80 percent of the change in the exchange rate being passed on within a year, producer and consumer prices respond much more sluggishly. Exchange rate pass-through to producer prices is modest while the pass-through to consumer prices is very limited. The influence from an exchange-rate shock on consumer price inflation is, therefore, rather limited, with less than 15 percent of an exchange rate change being passed onto consumer prices one year after the shock. This result is important for monetary policy makers when designing the right policy response to an exchange rate shock.

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