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Exchange-Rate Pass-Through to the Consumer Price Index: A Micro Approach

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Abstract

This research estimates the pass-through from the exchange rate to the Consumer Price Index for 31 components of the CPI, in an attempt to locate the sources of the pass-through, which has a significant effect on inflation and monetary policy in Israel. The rate of pass-through in general is about 29 percent, similar to that found in earlier research on the subject in Israel. It can also be seen that the pass-through has fallen in recent years with the stabilization of the exchange rate and the fall in inflation to levels prevalent in developed countries. In this research it was also found that the source of half of the pass-through was in the housing category, the result of widespread dollarization in the housing rental market, as well as of the method of calculation of the index of average prices of owner occupied dwellings. Further effects of dollarization can be seen in the prices of electricity, fuel and several other items. Most tradable goods have clear, positive pass-through, though this also holds true for a large number of nontradable goods and services. The effect of real activity in the economy on pass-through is not significant.

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I. INTRODUCTION

The pass-through from the exchange rate to prices is one of the most important and interesting macroeconomic processes in Israel. The effect of the exchange rate on inflation has been considered the major limitation on monetary policy in recent years in Israel, and has to a great extent influenced policy decisions in this context. Estimates of pass-through can be found in several papers on the subject in recent years, most of which estimate pass-through using equations of inflation that stem from broad macroeconomic models, or from a reduced form of such.

The major theoretical basis for the existence of a pass-through from the exchange rate to prices stems from the Law of One Price (LOOP) and from the principle of Purchasing Power Parity (PPP) which states that at equilibrium the price of a certain good in two markets cannot differ, when expressed in the same currency. A change in the exchange rate changes the price of the good in terms of the foreign currency, and therefore should cause a proportionate change in the price of the good in terms of the domestic currency. So the long-term pass-through between the exchange rate and prices ought to be complete, i.e. a 100 percent pass-through. As the PPP principle is far from holding true in practice,[1] most empirical studies worldwide do not point to full pass-through in the long term and certainly not in the short term.[2]

There could be several reasons why pass-through is not complete, or even nonexistent. One reason is due to nontradable goods, for which one would not expect the law of one price to hold. On the other hand, there are cases where pass-through exists when economic theory would expect no pass-through at all. The high inflation that was prevalent in Israel in the past brought with it almost complete indexation of housing prices to the exchange rate, even though housing services are a blatant example of nontradable goods. This type of dollarization still exists for other goods and services in Israel. Other types of indexation could also stem from price regulation, where the exchange rate is used as an indicator for a change in the state-regulated price.

These considerations raise the need to examine the relationship between the exchange rate and components of the consumer price index, separately. In this research we have attempted this, to the best of our knowledge for the first time in Israel, which allows us to locate the sources of the pass-through. The division of the consumer price index into several components helps us to examine different goods and services including those which, according to theory, should not demonstrate any pass-through, and others which, according to theory, should do so but do not, or at most only slightly.

This distinction of sources of pass-through could form the basis of policy recommendations for central banks, particularly in small, open economies such as Israel. Edwards (2006) notes that literature on the subject generally regards a

[1] For further details on some reasons why PPP does not hold true in practice see Soffer (2005).
[2] Examples of small, open economies that do not show full pass-through can be found in Croatia (Billmeier and Bonato, 2002), Brazil (Belaish, 2003) and others.

reduction of pass-through as a desired development. A drop in pass-through lowers inflationary pressures that originate overseas or from developments in the foreign exchange market which have no direct link to the factors that affect the domestic level of prices. High pass-through also increases the volatility of inflation as well as the monetary policy that is designed to deal with it. Furthermore, it raises questions about the ability of the exchange rate to serve as a cushion against real shocks by changing the relative prices between tradable goods and nontradable goods. This ability depends on nominal changes in the exchange rate influencing the real exchange rate. In this context, a high pass-through from the exchange rate to prices of tradable goods is what enables the adjustment of the real exchange rate while a high pass-through in nontradable goods tempers this adjustment and allows shocks to influence the local economy far more so. From a different point of view (Fischer, 2006), high pass-through could be seen as advantageous in terms of monetary policy's effectiveness, for if the exchange rate is highly responsive to the interest rate, a change in interest rate would affect prices quickly via the exchange rate, thus making it easier for the policy to achieve its inflation target within a short time.

This paper is set out as follows: Part 2 presents the background, in theory and literature; Part 3 describes the characteristics and prevalence of dollarization in Israel; Part 4 presents the database and describes the econometric approach of this research; Part 5 presents the findings and discusses them. Part 6 concludes.

II. BACKGROUND IN THEORY AND LITERATURE

The basis for the existence of a pass-through from the exchange rate to domestic prices stems, as mentioned earlier, from the PPP principle. The world price of tradable goods permeates to the local price through two possible channels:

a) Imported goods, which become more expensive as the local currency weakens, and then these directly affect the imported component of the domestic price index, and indirectly affect home-produced substitutes to the imported goods. In this description we assume full pass-through between the exchange rate and the local price of the imported goods. Extensive literature, both theoretical and empirical, deals with this pass-through[3] and often the findings do not support full pass-through, that is there are cases where when the domestic currency weakens, the price of the imported good in terms of foreign currency falls, and the exporter abroad is the one that must absorb the change in the exchange rate (either partly or in full). In Israel it is generally assumed that the price in foreign currency of imported goods is exogenous to the exchange rate of the shekel[4] although this assumption, to the best of our knowledge, has not been checked. The fact that Israel is a small and open economy does not necessarily mean there is full pass-through between the exchange rate and prices of

[3] The literature differentiates between Local Currency Pricing (LCP) and Producer Currency Pricing (PCP) mechanisms.
[4] That is the mechanism of setting the price is PCP.

imported goods: there are studies which estimated the relationship between the exchange rate and prices of imports in small economies, and full pass-through was not always found.[5]

b) The second channel is that of exported goods. Assuming that the prices of these goods are set abroad[6], so a weakening of the local currency makes the exported goods more expensive in terms of the local currency, and this would trickle down to exportable goods that are sold domestically.

These mechanisms do not explain pass-through between the exchange rate and the prices of nontradable goods. Such an explanation may be found for example in a model of tradable and nontradable goods, which states that when tradable goods become more expensive following a depreciation in the currency this raises the value of marginal production in terms of the local currency of the workers in the tradable sector, and this leads to a rise in nominal wages. A rise in wages impacts the nontradable sector too and raises prices there. If that is the case, the strength of the pass-through is dependent on the local structure of demand and supply of the two types of goods.

Various studies have attempted to find reasons for the relatively low level of pass-through in recent years, in imported goods as well as in the consumer price index. Engel (2002) quotes models that state that the price of an imported good is itself only a small part of the final price to the consumer: on top of the price to the importer, local costs of distribution, storage, marketing, sales, etc. must be added. In practice, a significant part of the price to the consumer of a tradable good represents nontradable services, and so the increase in the global price of an imported good would bring a disproportionately smaller increase in the local price. Another possibility is that the imported good is a raw product used in the production of a domestic final good, and when raw material becomes more expensive the local manufacturer can substitute it to come extent with local raw materials, and this will weaken the pass-through even more.

A low pass-through is also associated with the level of permanence in the changes in the exchange rate. Taylor (2000) presents a simple model in which firms have a certain level of market power, and therefore each firm sets the price of its goods in the market, as opposed to a competitive situation where the price of the product is exogenous to the firm. However setting a price is a costly process[7] and so each firm sets a price once in each four periods, that is, the economy consists of four groups of firms, and each group sets a price in a different period.[8] As a result, the firm must evaluate its cost structure and the demand that will prevail in the next three periods

[5] Israel's GDP is about 0.3 percent of global GDP. Campa and Goldberg (2002) found long-term pass-through significantly different from one, for New Zealand (0.2 percent of global GDP), Greece (0.4 percent of global GDP), Spain (2 percent of global GDP) and others.

[6] According to the LCP mechanism.

[7] Menu cost is a familiar term in literature. Levy et al. (1997) researched the mechanisms of changes in prices among the five largest retail chains in the US, and concluded that adjusting prices costs the chains 0.7 percent of revenues, or $0.50 for each change in price, or about one cent for each item sold.

[8] A price-setting mechanism was first suggested by Taylor (1980) in his study of wage-setting.

when the exchange rate is part of the cost structure of the firm due to its use of imported raw materials. The model shows that if there is a change in the exchange rate in the period of price setting but it is regarded as only a temporary change, then pass-through will be far lower than if the change in the exchange rate was expected to be permanent, as in the following periods the price cannot be readjusted. In an Israeli context, one can expect for example that the pass-through was lower in recent years when the exchange rate fluctuated with no fixed trend, as opposed to the 1990s during most of which there was a recognized trend of a depreciating shekel.[9] The associated costs of price-changing could also lead to a non-linear pass-through, that is the firms will change the price only following a considerable change in the exchange rate or when there are expectations of such a change, while they would leave the price as is following a minor change in the exchange rate.

The state of the macroeconomy, together with the competitive structure of the market, could also influence the pass-through. If we assume again that producers have certain market power, so in accordance with the state of the economy they could decide to change their profit margins when the exchange rate changes. For example, if the currency depreciates when the economy is in recession, the manufacturers are likely to absorb most of the increase in costs and so pass-through at a time of depreciation will be lower in times of recession and higher in times of economic growth. Similarly it could be claimed that if the currency appreciates in times of economic boom, manufacturers could try to increase their profit margins at the expense of the consumers, such that prices would fall less than the appreciation dictates. So pass-through at times of appreciation is expected to be weaker if the economy is in a period of growth.[10]

A number of studies refer in one way or another to pass-through between the exchange rate and prices in Israel. Bufman and Leiderman (1998) found a cumulative pass-through of the exchange rate multiplied by dollar prices of imported goods at a rate of 28 percent for the years 1988–1996, and when the effect on inflation was examined without housing, a lower coefficient was found, of 11 percent. Leiderman and Bar-Or (2000) found a particularly high cumulative pass-through[11] of about 50 percent when the economy is in a state of full employment, compared to a pass-through of around 40 percent in a recession. They also found a stronger link between the exchange rate and prices in the last quarter of 1998 when the shekel depreciated considerably against the dollar. Bufman and Leiderman (2001) calculated the Impulse Response Function using a VAR model and found that the cumulative pass-through from the exchange rate to inflation after ten quarters was 40 percent in the period 1988–1994. The authors also identify a drop in pass-through to a particularly low

[9] For these reasons it is claimed, for example in the Bank of Israel Annual Report 1999 (Page 94, English version) that the pass-through in Israel contracted with the widening of the exchange-rate band, which caused the public to internalize that the shekel could appreciate nominally for lengthy periods.
[10] Economic theory generally shows that at times of recession, conditions for real depreciation are created, and vice versa. This behavior of pass-through will bring an expected change in the real exchange rate according to the state of the economy.
[11] The structure of the equation, in this study as in others mentioned earlier, allows for simultaneous effects and one-lagged effects only of the exchange rate.

level of 10 percent in the years 1995–2000 as a result of the moderation in inflation and depreciation rates with the advance of the disinflation process in Israel. Elkayam (2003) estimated an equation to explain inflation, *inter alia*, using a variable of global prices, that is, dollar import prices multiplied by the exchange rate, for the years 1989–2003. Surprisingly, the pass-through coefficient for the short term is far lower for the first part of the period (1989–1997, pass-through of 18 percent) than for the second part (1997–2003, pass-through of 28 percent), although the difference in the coefficients is not significant. The estimate of the impulse response function in the VAR model, however, shows that the effect of a shock in the exchange rate on inflation was shorter in the second period, due to the policies of the Bank of Israel to reduce inflation. Barnea and Djivre (2004) estimated a macroeconomic model for the Israeli economy for 1990–2002 under an inflation targeting regime and a flexible exchange rate. Their inflation equation found an effect of 28 percent from the exchange rate and import prices on inflation.

The Israeli case has also been used by a number of researchers worldwide, who wanted to make an international comparison regarding pass-through in different countries: Choudhri and Hakura (2001) examined the effect of the inflationary environment on pass-through in a sample of 71 countries, and found that the pass-through in Israel fell from a level of 83 percent in the hyperinflation years (1979–1985) to 28 percent in the years after the Stabilization Plan (1985–2000). Edwards (2006) examined seven countries which adopted an inflation target regime, and found that pass-through was always weaker after adopting such a regime: In Israel for example pass-through stood at 62 percent in the years 1986–1991, and then fell significantly to 19 percent in 1992–2005.

III. DOLLARIZATION IN ISRAEL

The term dollarization refers to the use of a currency from another country as a substitute for the local currency. Calvo (2002) however defines "partial dollarization" as the situation where a foreign currency fulfills only some of the classic roles of money—means of payment, store of value or a unit of account—compared to "full dollarization" which is where a state totally adopts a currency of another state (not necessarily the dollar) which fulfills all three roles of money, and in effect the country has no currency of its own. Hereafter, the term dollarization in this paper refers principally to the Israeli public's use of a foreign currency as an alternative to the local currency in its role as *a unit of account*.

As a result of a long period of high and persistent inflation, the Israeli economy developed several indexation arrangements, which linked prices of various goods and services to the exchange rate and/or to the consumer price index. A detailed list of these arrangements can be found in a Bank of Israel position paper,[12] and a historical review with general analysis can be found in Schiffer (1999). In recent years, some of

[12] "Indexation in Israel in a low inflation environment - Description and some recommendations" 9/7/00.

these exchange-rate indexation arrangements have disappeared: outstanding examples include the Israeli government's cessation of issuing dollar-linked (*Gilboa*) government bonds and the cancellation of foreign-exchange indexation of all government fees. However there are still a number of arrangements and practices indexed to foreign currency, which we can assume positively affect the pass-through from exchange rate to CPI:

- Tariffs for the Israel Electric Corporation. Electricity prices in Israel are set by the Public Utility Authority - Electricity. This arrangement compensates the Israel Electric Corporation for rises in current expenses and financing expenses which stem from liabilities in foreign currency, both operational and financing. This arrangement causes a pass-through of 82 percent between the currency basket to the electricity component in the consumer price index.[13]
- Setting the price of those fuel products under state supervision. The prices of fuel products sold at Oil Refineries' gates, are set once a month by the Ministry of Energy and National Infrastructure according to the going fuel prices in the Mediterranean basin at the end of each month. This price, set in dollars, is converted at the going exchange rate in order to reach the Oil Refineries gate price in shekels. This is only a small part of the price to the consumer, as there are further shekel components added on top of the Oil Refineries gate prices. Appendix 1 details the process of setting the price, and finds as an example in May 2006 that a depreciation of 1 percent in the exchange rate should have brought about a change of 0.47 percent in the consumer price, *ceteris paribus*. One must note that in earlier periods, the pass-through from the exchange rate was lower, given that world oil prices were lower, while the other components of the price were fixed in shekel terms.
- Prices that are "traditionally" stated in foreign currency terms. Despite a clause in the Consumer Protection Law forbidding the setting of prices for goods and services in foreign currency, prices in several fields are still traditionally quoted in foreign currency:
    - The most obvious example is in the rental housing market, where still most of the contracts are quoted in foreign currency: a survey by the Ministry of Housing[14] in 2000 found that 77 percent of rental contracts were indexed to foreign currency in one way or another. Yet in the housing sample used by the Central Bureau of Statistics for setting the rental housing price index, more than 90 percent of the contracts were quoted in foreign currency (see Table 6). One could regard this as unwanted, and a market failure: usually neither the tenant nor the renter have any parallel income or expenditure flow in foreign currency and the indexation of the rental contract to the exchange rate—a leftover of an old habit—exposes them to a superfluous risk, particularly in periods where the exchange rate follows no expected trend pattern. Moreover, this foreign currency element of the

[13] According to calculations by R. Levy (2004). "The Implications of the IEC Tariff Arrangement on Managing Exposure and the Pass-through Mechanism", Bank of Israel, internal paper.
[14] Mentioned in the Bank of Israel position paper – see footnote 12.

housing rental market affects the new and second-hand housing market too.[15]

- Prices of legal services, jewelry, car rentals, parties and functions (catering, halls etc.) have been identified by the CBS as also being quoted in foreign currency, or, following the amendment to the Consumer Protection Law which forbids businesses from quoting prices in foreign currency, are quoted in shekels with the price linked to the exchange rate. Here also at least some of these examples deal with local, nontradable services with no economic logic for their prices to be linked to the exchange rate.
- Prices of foreign travel are generally quoted in foreign currency as airlines and travel agencies are exempt from the amendment to the Consumer Protection Law.

- Various instructions in the Income Tax Ordinance. There are various instructions in the Income Tax Ordinance that deal with businesses whose major activities are in foreign currency, managing their books in foreign currency and setting their income accordingly. In addition, the law on adjustments due to inflation includes instructions on calculating indexation based on changes in the exchange rate, defined as the representative rate of the dollar, concerning assets bought overseas in foreign currency. Although these instructions have no direct effect on consumer prices, they certainly do affect companies' calculations, and cause companies to give greater emphasis on changes in the exchange rate when setting the prices of their goods.

IV. DATABASE AND ESTIMATION APPROACH

A. Background

The choice of database for this paper was influenced by two factors: first was the wish to check how far the theoretical hypothesis—that the pass-through in tradable goods will be much higher than for nontradable goods—is found in practice. And the second factor was the wish to try and identify the effect of dollarization in Israel on pass-through, and also to locate if and how much the authorities influence pass-through via the mechanisms for setting prices on goods whose prices are controlled.

The literature is not overflowing with research that estimates the pass-through from the exchange rate to the consumer price index in a disaggregate manner. In practice, this approach is far more widespread in studies that check pass-through on import prices,[16] given that international definitions are more or less standard and it is easy to match series of local import prices with series of export prices of the country of origin. A number of studies broke the CPI down into a small number of components: Belaisch (2003) estimated the pass-through from the exchange rate in Brazil to four categories of CPI; tradables and nontradables, supervised and non-supervised goods,

[15] According to conversations with people working in the housing sector.

[16] For example, Campa and Goldberg (2002), Campa and Gonzales (2004), Adolfson (1997), Takagi and Yoshida (2001). Research that will check the entire link from the exchange rate to import prices and from there to wholesale prices and finally to the consumer is still required in Israel.

as well as to the general index and to the wholesale price index. He found high pass-through for tradables, and a lower (albeit significant) pass-through for the nontradables. The supervised products reacted to the exchange rate more rapidly, albeit to a lesser extent, than the non-supervised products. Taking Estonian data, Dabusinskas (2003) estimated the pass-through from the exchange rate to ten import components, to the wholesale price index, to the consumer price index and to the tradable component of the consumer price index. Despite a pass-through of 40-50 percent to import prices, there was no pass-through found to either the consumer price index or to its tradable component.

One paper written in Canada, Leung (2003), is the only one[17] that examines the pass-through in the same disaggregate fashion as we do here. Leung splits the Canadian consumer price index into dozens of components, and finds pass-through principally in the food components. He believes that the difficulty in finding a pass-through in the other components could stem from the high volatility of the sub-components compared to the aggregate; on estimating the pass-through to the general index, he found a pass-through of 0.17 percent from the exchange rate to the CPI in the long run.

B. Data

We split the consumer price index series into 31 subsidiary series as detailed below. The index usually published by the CBS contains 10 major components (see Table 1). Each of these components was further divided into four sub-components—controlled tradables, non-controlled tradables, controlled nontradables, and non-controlled nontradables.[18] The division was made according to the series' weighting in the index for 2005. In some special cases, exceptions were made in the categorization in order to isolate or to aggregate series with the same special interest. Eventually we ended up with the series shown in Table 2.

Table 1: The major components of the Consumer Price Index

CPI component	**Weighting in 2005**
Food excl. vegetables and fruit	139.3
Vegetables and fruit	33.2
Housing	216.2
Household maintenance	103.8
Furniture and household equipment	42.6
Clothing and footwear	29.9
Health	50.6
Education, culture and entertainment	128.6
Transport and communications	211.9
Miscellaneous	43.9
Total	1000

[17] Actually Demers and Champlain (2005) estimated an equation, separately, for 19 items of the consumer price index in Canada but the emphasis of their work was on different methods of forecast and not necessarily on the calculation of pass-through from the exchange rate.

[18] The classification of goods is taken from that of the existing list at the Bank of Israel, based on Ben-Bassat 1992.

As mentioned earlier, according to the PPP principle a change in the world price could roll over to the price in the local currency in two ways: either through a change in the exchange rate or through a change in the world price of the good in terms of foreign currency. Theoretically, if the Law of One Price applies and the local price is meant to exactly reflect the world price, then the pass-through from the world price in foreign currency terms should be equal to 100 percent, exactly like the pass-through from the exchange rate. And as mentioned earlier, several studies in Israel did not differentiate between the exchange rate and the world price in foreign currency terms, but estimated an equation in which the world price in shekel terms constituted a single variable. But this assumption need not always be so: in literature[19] several reasons are proposed for why pass-through from the exchange rate and from the world price need not be identical. For example, the exchange rate generally is more volatile than the world price, which is likely to lead to a lower pass-through. On the other hand, the world price is not always known to the general public and so local consumers find it easier to "justify" a change in price that stems from the exchange rate as opposed to changes that stem from the world price. The existence of mechanisms of indexation to the exchange rate (but not to world prices) in Israel is also likely to lead to differences in pass-through from the exchange rate and from the world price.

[19] For example Mihaljek and Klau (2001).

Table 2: Division of the CPI into series for estimation

Series No.	Weight in CPI	T/N*	C/NC**	Definition	Main Components
1	10.6	T	NC	Tradable veg. and fruit	Frozen, preserved and canned veg. and fruit
2	22.6	N	NC	Nontradable veg. and fruit	Fresh veg. and fruit
3	32.7	N	C	Nontradable controlled food	Bread, dairy products
4	41.8	N	NC	Nontradable non-controlled food	Fish, cakes, dough products, eggs, meals away from home
5	8.1	T	C	Controlled tradable food	Flour, beef
6	56.7	T	NC	Tradable non-controlled food	Other meat and food, drinks, fats etc.
7	216.2	N	NC	Housing	Owner-occupied housing, rent, other housing expenses
8	4.1	N	C	Gas	
9	23.3	N	C	Municipal taxes	
10	27.5	N	C	Electricity	
11	9.7	N	C	Water	
12	37.7	N	NC	Household maintenance	Domestic help, house and yard maintenance, miscellaneous household utensils
13	1.5	T	C	Fuel for household use	
14	42.6	T	NC	Furniture and household equipment	Furniture, bedding and home decorations, home and kitchen equipment (electrical and nonelectrical)
15	0.9	N	NC	Nontradable clothing and footwear	Clothing repair, laundry away from home etc.
16	29	T	NC	Tradable clothing and footwear	All types of clothing and footwear
17	2.8	N	C	Books and study materials	
18	36.8	N	C	Controlled education	Kindergartens, schools and higher education
19	50.9	N	NC	Non-controlled education, culture and entertainment	Lectures and training courses, newspapers and magazines, religious equipment, movie houses and
20	38.1	T	NC	Tradable culture and education	Books, television etc., hobbies, toys
21	12.1	N	C	HMO services	
22	22	N	NC	Private medicine	
23	16.5	T	NC	Medication and medical equipment	
24	10.7	N	C	Public transport	Taxis, buses, trains and domestic flights
25	39.8	N	C	Communications services	Phone and mail
26	3.8	N	NC	Driving lessons, car rental etc.	
27	87.3	T	NC	Car and maintenance	(Excl. fuel and oils)
28	36.3	T	NC	Overseas travel	
29	12.1	N	NC	Nontradable miscellaneous	Hairdressing, beauty parlors, legal and other services, fees etc.
30	31.8	T	NC	Tradable miscellaneous	Cigarettes, washing goods, jewelry, watches, bags etc.
31	34	T	C	Fuel and oils for vehicles	
Total	**1000**				

* Tradable/non-tradable

** Controlled/non controlled.

In this paper we also chose to differentiate between the exchange rate and the world price in terms of foreign currency. In order to do this, a suitable world indicator for each of the tradable components of the CPI had to be found. Such a task is not to be taken for granted: some of the works referred to earlier and which estimated a pass-through to import prices used, as mentioned, weighted export prices based on trade partners, as the world price. However it is harder to make such a match with the CPI,

particularly in Israel's case where there are many countries of origin of imports.[20] That being the case, in most instances we decided to find a component in Israeli imports that was suitable for a component of the CPI being examined, with world fuel prices considered a particularly good indicator in some other cases. The use of disaggregate import prices also dictates the frequency and duration of the sample: these data occur only quarterly, from 1991, with the sample of this paper ending in the fourth quarter of 2004. Another issue touches the nontradable goods: if the assumption of this research is at least in part that there is no direct pass-through from the exchange rate to the price, then we must find another variable which can explain the change in these prices over time. In some of the series we matched a price of a good which constitutes a raw material in the manufacture of that good or nontradable service. In other cases, in line with the basic model of tradable and nontradable goods as mentioned earlier, we chose to put into these equations of goods the nominal wage for an employee post in the business sector as an additional explanatory variable of the exchange rate.[21] Table 3 details the series of prices that serve as additional explanatory variables for the exchange rate in our estimation equation.

The exchange rate that serves as an estimate is the average dollar-shekel exchange rate in the quarter. It may have been more correct to choose the effective exchange rate that represents the sources of import and destinations of export of the Israel economy. Such an exchange rate for example was calculated in an earlier study (Soffer, 2005), but the use of such an index would have necessitated the use of similar effective import prices, that is import prices weighted by the country of trade. Drawing up such indexes would be very cumbersome. So the pass-through calculated in this research is the pass-through from the dollar exchange rate to the consumer price index, where if there are relevant changes in the cross exchange rates, then they will be expressed in the dollar price of imports.[22]

Each series of local and world prices was seasonally adjusted and each series, including the exchange rate, is a natural logarithm of the original series or seasonally adjusted, respectively.

[20] Leung (2003) found similar components in the consumer price index for the US in order to reflect the world price for prices in the Canadian CPI.
[21] Disaggregate data on wages are available, though these force our sampling to start only in 1994.
[22] For example, the strengthening of the Japanese yen against the shekel and the dollar could be expressed in the price of cars in Israel so that the dollar price of an imported car would rise, and then there would be pass-through from the import price and not from the exchange rate.

Table 3: Indicators for world prices or for local production costs

Series No.	Definition	World Price Indicator or Other Indicator
1	Tradable veg. and fruit	Unit value of exports - agricultural goods
2	Nontradable veg. and fruit	Unit value of raw material imports – for agriculture
3	Nontradable controlled food	Unit value of raw material imports – basic foods
4	Nontradable non-controlled food	Unit value of raw material imports – basic foods
5	Controlled tradable food	Unit value of consumer good imports – food
6	Tradable non-controlled food	Unit value of consumer good imports – food
7	Housing	Wages
8	Gas	World gas prices
9	Municipal taxes	Wages
10	Electricity	Unit value of raw material imports – fuel, oils
11	Water	Unit value of raw material imports – fuel, oils
12	Household maintenance	Unit value of consumer good imports –for household maintenance
13	Fuel for household use	World oil prices
14	Furniture and household equipment	Unit value of imports – basic furniture, other furniture, household equipment
15	Nontradable clothing and footwear	Wages
16	Tradable clothing and footwear	Unit value of consumer good imports – clothing and footwear
17	Books and study materials	Unit value of raw material imports –for paper production
18	Controlled education	Wages
19	Non-controlled education, culture and entertainment	Wages
20	Tradable culture and education	Unit value of consumer good imports – for entertainment and hobbies
21	HMO services	Wages
22	Private medicine	Wages
23	Medication and medical equipment	Unit value of consumer good imports – medication
24	Public transport	World oil prices
25	Communications services	Wages
26	Driving lessons, car rental etc.	Wages
27	Car and maintenance	Unit value of consumer good imports – cars
28	Overseas travel	World oil prices
29	Nontradable miscellaneous	World oil prices
30	Tradable miscellaneous	Unit value of consumer good imports - cosmetics, jewelry, watches, gems, tobacco and cigarettes
31	Fuel and oils for vehicles	World oil prices

C. Estimation

It is natural to think of the cointegration as a suitable framework for estimating PPP relationships—in the long run a change in the world price or in the exchange rate should roll over onto the local price, and the error correction equation could express the short-term pass-through. However estimating a cointegration equation was not carried out in this paper for several reasons. First, for some of the series the ADF test significantly rejected the hypothesis of a unit root. Secondly, initial tests of cointegration showed that even for those series that had unit roots, the null hypothesis of no cointegration was generally not rejected at a significant level. Given that in the vast majority of series of differences the hypothesis of a unit root was rejected in ADF tests[23] we chose to estimate the relationship using the Auto Regressive Distributed Lag (ARDL) method, where the basic equation of estimation for each component is given by:

$$dP_{it} = a_u + \sum_{j=1}^{k} \alpha_{ij} dP_{i,t-j} + \sum_{j=0}^{k} \beta_{ij} dUSD_{t-j} + \sum_{j=0}^{k} \gamma_{ij} dPW_{i,t-j} + \varepsilon_{it} \qquad (1)$$

where:

P_i – log of the price index of the *i* component of the CPI (*i*=1,2,……31)

USD – log of the average exchange rate of the shekel against the dollar in the quarter

PW_i – log of the relevant world price index (such as import price) or local price index (such as nominal wage)

ε_i – random error term

d – differential operator

k – number of lags in the regression.[24]

The meaning of estimating the differences while ignoring the possible existence of cointegration relationships between the exchange rate and the components of the consumer price index is that we do not force a long-run convergence of the local price and the world price on the system. If at any time there is a permanent shock to the *level* of the exchange rate, for example, while the shock to the *level of change* in the exchange rate is but transitory (which stems from the fact that the series of depreciation in the exchange rate is I_0), then the assumption is that the shock will not be permanent at the level of the estimated component of the consumer price index. In any case if there is such a change, it will not be caught by the estimation described above given that we have not chosen to estimate an error correction system.

From equation (1) we wanted to extract the pass-through over time of the change in the exchange rate on inflation for each component. The general pass-through is the weighted total of the pass-through for all the components, with the weight being the weight of that component in the CPI in 2005. The simultaneous pass-through of the

[23] The results of the ADF tests are presented in Appendix 2. For those series where the hypothesis of a unit root was not rejected, the results were generally sensitive to the number of lags in the test, and in every case when a trend was added to the test the hypothesis was rejected.

[24] We estimated the equations to various specifications between one and four time lags. The results presented are with two time lags.

exchange rate is trivial, and is equal to the simultaneous coefficient of the exchange rate in equation (1):

[25] $EPT_0 = \beta_{i0}$

From here, the pass-through in each subsequent quarter is in effect the Impulse Response Function (IRF) which describes the behavior of the price index following a shock of one unit (as the difference is shown in logs, this is in effect a shock of 1 percent) in the exchange rate. So the pass-through in the quarter following the shock is given as :

$$EPT_1 = \beta_{i1} + \beta_{i0} \cdot \alpha_{i1}$$

and in the next quarter:

$$EPT_2 = \beta_{i2} + \alpha_{i1}(\beta_{i1} + \beta_{i0} \cdot \alpha_{i1}) + \alpha_{i2}\beta_{i0}$$

and so on.

Before estimating the equation, the possible problem of endogeneity must be addressed. As we know, the assumptions of the basic regression are that the explanatory variables are not correlated to the residual of the equation. In equation (1) it could be claimed that the exchange rate is an endogenous variable given that it could be influenced by a shock in prices. One could think, for example, of a mechanism in which the Bank of Israel has a reaction function, in which it responds to a positive shock in the consumer price index by raising the interest rate, with the rise in interest simultaneously affecting the exchange rate. Other studies[26] dealt with this problem by removing the simultaneous depreciation from the equation. This is possible providing that we assume that the pass-through is not simultaneous but rather starts after a time lag of one period. This assumption does not appear reasonable in the Israeli economy particularly with quarterly data. The assumption in our research was that as each explanatory variable constitutes, separately, a relatively small component of the consumer price index—the largest single component being the housing component, with a 21.6 percent weighting—then it is unreasonable for the Bank of Israel to respond to a shock in any one of the components separately with a rise in the interest rate. Nevertheless, we carried out the Hausman test for endogeneity, described in full in Appendix 3 (including results). After running the test on each of the 31 equations we can see that the vast majority of the equations do not suffer the problem of endogeneity, and moreover, only in one series does endogeneity recur in each number of lag periods and in each specification of equation.[27] If so, we can estimate equation (1) using the OLS method, and the estimates will be unbiased.

[25] EPT=exchange rate pass-through.
[26] Leung (2203), Demers and Champlain (2005).
[27] A further specification of our estimation of equation (1) will be described later. The results in the appendix show the test results for this specification also.

An additional question touches on the significance of the pass-through: there is nothing stopping us from obtaining a value different from zero for each of the expressions above, but it is important to distinguish between significant and non-significant results, especially since we add up all the results without considering the standard deviation of each calculated pass-through in the summation. Enders (2004) notes that there is nothing to prevent us from calculating the statistical value of the coefficient β_i^0 assuming that it is normally distributed. However in order to calculate the next statistical values of the IRF, one must make assumptions regarding the distribution of the coefficients, and hence regarding the covariance between the coefficients, as the IRF are obtained by multiplying the coefficients from the regression. Enders proposes solving this problem by running a Monte Carlo simulation which makes no previous assumption about the distribution of the coefficients, thus:

1. Run equation (1), and calculate the IRF. We denote the coefficients estimated in the equation as $\hat{a}_i, \hat{\alpha}_{ij}, \hat{\beta}_{ij}, \hat{\gamma}_{ij}$ and the residual as $\hat{\varepsilon}_i$.
2. Randomly resample the series of residuals, so that we get a new series of residuals with the same statistical distribution. We will mark the random residual series ε_i^1.
3. Construct the series of explanatory variables again artificially, using the coefficients from the original estimation, the explanatory variables and the new residuals:

$$dP_{it}^1 = \hat{a}_i + \sum_{j=1}^{k} \hat{\alpha}_i^j dP_{i,t-j} + \sum_{j=0}^{k} \hat{\beta}_i^j dUSD_{t-j} + \sum_{j=0}^{k} \hat{\gamma}_i^j dPW_{i,t-j} + \varepsilon_{it}^1 \qquad (2)$$

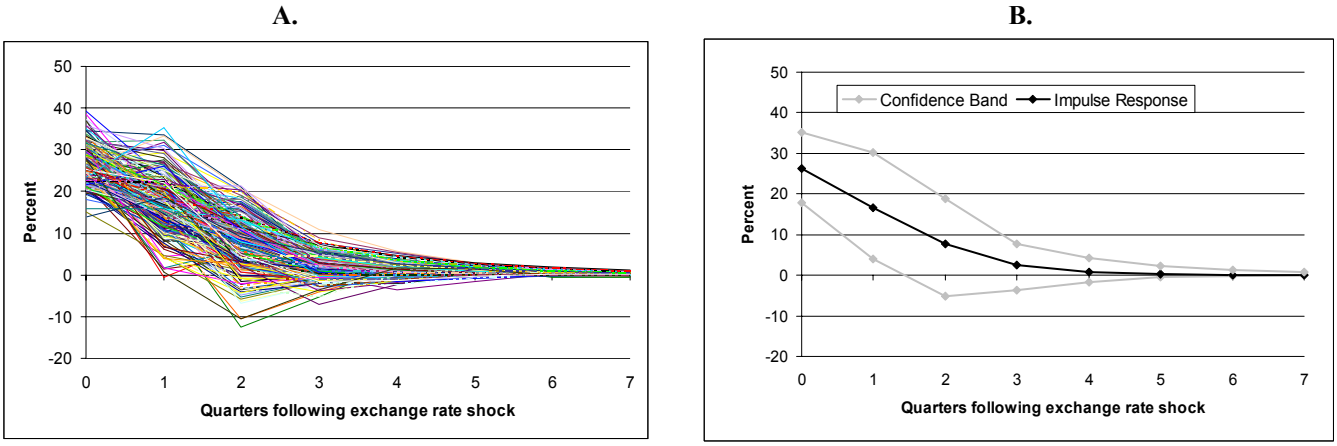
4. Now assume that we do not know the values of the coefficients that we used to build this artificial series, and estimate the regression afresh with the explanatory variable now the artificial series. Calculate afresh the IRF and obtain the residuals ε_i^2 again.
5. When this process is repeated time and again, several IRF are obtained. These serve to represent the whole distribution of the original IRF, and it is possible to create a confidence interval, for example, of 95 percent by "chopping off" the upper and lower 2.5 percent of the IRF. So if the confidence level does not contain the zero value, we can say that at the 95 percent significance level the IRF is different from zero or the pass-through is significant.

We used Enders'[28] procedure to set the significance of the pass-through estimated from each equation, with the confidence level we chose at 5 percent, and we reiterated this procedure 1000 times for each equation. Figure 1 presents an example of the process, with the right hand side showing the whole distribution of the 1000 Impulse Response Functions, and from the left hand side we derive the confidence interval at a confidence level of 95 percent. It can be seen that the graph represents a component of the CPI for which the simultaneous rate of pass-through is 27 percent, in the first

[28] As an alternative to this method the significance of the Impulse Response Function could be tested by a WALD test. The results of such a test appear in Appendix 5.

quarter a rate of 17 percent, and in the second quarter the pass-through rate is 8 percent, though it is not significantly different from zero, given that the confidence interval contains the value zero.

Figure 1: A. Distribution from 1000 Impulse Response Functions. B. Confidence Interval of 95 percent



V. RESULTS AND DISCUSSION

A. General

The pass-through obtained from estimating equation (1), is presented in Table 4 while referring only to the IRF that were found significant by the methodology described above.[29] One can see that apart from six items, in all items of the index there is a positive and significant pass-through from the exchange rate to the consumer price index. We cannot differentiate significantly between tradables and nontradables, and between controlled and non-controlled goods.

It is possible that part of the pass-through registered in nontradable goods or services with a clear local orientation (municipal taxes, books and study materials, controlled education, HMO services, communications etc.) is in fact not pass-through from the exchange rate but pass-through from the consumer price index itself, which was not caught even when we used wages as an explanatory variable in our equations for these items. It is known that the prices of many state-provided services are indexed one way or another to the consumer price index, and in the business sector too a rise in the index constitutes an indicator of a change in prices. Moreover, in order to calculate the components of the CPI, the CBS uses the overall index to cover for missing observations.[30]

[29] All of the equations were estimated by beginning with one time lag and including up to four time lags. The results shown are those for estimations with two time lags, given that with this estimation the results at all specifications were stable, the IRF always converged to zero and the IRF were always obtained in the center of their distributions up to at least four periods.

[30] For example, in the "academic studies" clause the price for October is measured, and then recalculated according to the change in the overall index. These adaptations are also made to the "other education", and "various government fees" clauses as well as for items not sold out of season.

Table 4: Pass-through obtained from the estimation of equation (1)

			Pass-through (%) in quarter:									
Series no.	Definition	Weight in CPI	0	1	2	3	4	5	6	7	Cummulative pass-through for component (%)	Component's contribution to overall pass-through (%)
1	Tradable veg. and fruit	10.6	0.0	14.4	12.0	0.0	0.0	0.0	0.0	0.0	26.4	0.3
2	Nontradable veg. and fruit	22.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Nontradable controlled food	32.7	0.0	12.9	16.0	7.2	0.0	0.0	0.0	0.0	36.2	1.2
4	Nontradable non-controlled food	41.8	0.0	9.8	0.0	0.0	0.0	0.0	0.0	0.0	9.8	0.4
5	Controlled tradable food	8.1	14.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7	0.1
6	Tradable non-controlled food	56.7	0.0	15.5	25.2	0.0	0.0	0.0	0.0	0.0	40.7	2.3
7	Housing	216.2	70.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.7	15.3
8	Gas	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Municipal taxes	23.3	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.6	0.4
10	Electricity	27.5	20.5	49.0	17.2	0.0	0.0	0.0	0.0	0.0	86.7	2.4
11	Water	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	Household maintenance	37.7	7.9	11.2	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.7
13	Fuel for household use	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Furniture and household equipment	42.6	26.6	21.9	18.0	9.8	6.0	0.0	0.0	0.0	82.4	3.5
15	Nontradable clothing and footwear	0.9	0.0	8.7	0.0	0.0	0.0	0.0	0.0	0.0	8.7	0.0
16	Tradable clothing and footwear	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	Books and study materials	2.8	0.0	9.9	9.6	4.6	3.5	0.0	1.3	0.0	28.9	0.1
18	Controlled education	36.8	15.1	10.3	0.0	0.0	0.0	0.0	0.0	0.0	25.5	0.9
19	Non-controlled education, culture and entertainment	50.9	27.4	8.7	0.0	0.0	0.0	0.0	0.0	0.0	36.1	1.8
20	Tradable culture and education	38.1	21.8	21.5	11.8	0.0	0.0	0.0	0.0	0.0	55.1	2.1
21	HMO services	12.1	24.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.6	0.3
22	Private medicine	22.0	5.4	10.7	7.7	0.0	0.0	0.0	0.0	0.0	23.9	0.5
23	Medication and medical equipment	16.5	0.0	13.7	20.3	0.0	0.0	0.0	0.0	0.0	34.1	0.6
24	Public transport	10.7	0.0	19.0	22.5	8.6	9.0	0.0	3.7	0.0	62.8	0.7
25	Communications services	39.8	0.0	34.1	0.0	0.0	0.0	0.0	0.0	0.0	34.1	1.4
26	Driving lessons, car rental etc.	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	Car and maintenance	87.3	12.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	1.1
28	Overseas travel	36.3	63.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.5	2.3
29	Nontradable miscellaneous	12.1	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	8.3	0.1
30	Tradable miscellaneous	31.8	17.0	23.3	12.9	0.0	0.0	0.0	0.0	0.0	53.1	1.7
31	Fuel and oils for vehicles	34.0	27.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.8	0.9
	Total pass-through in quarter		25.8	9.0	5.1	0.8	0.4	0.0	0.04	0.0		**41.1**

In order to validate this assumption, we created for each of these series a series of the consumer price index net of that series, and added this variable as an explanatory variable to equation (1). We then estimated the following equation:

$$dP_{it} = a_i + \sum_{j=1}^{k} \alpha_i^j dP_{i,t-j} + \sum_{j=0}^{k} \beta_i^j dUSD_{t-j} + \sum_{j=0}^{k} \gamma_i^j dPW_{i,t-j} + \sum_{j=1}^{k} \theta_i^j dEXCLP_{i,t-j} + \varepsilon_{it} \quad (3)$$

where $dEXCLP_i$ is the consumer price index net of series i. The pass-through obtained as a result of estimating this equation is presented in Table 5.[31]

[31] Detailed results of the regression on equation (3) can be found in Appendix 4, and a graphical presentation of the IRF of each of the equations in Appendix 5.

Table 5 shows that the addition of the dEXCLP variable reduced, if not completely removed, the significant pass-through for at least some of the clauses which were not expected to have pass-through. From this table we can reach two general conclusions: the overall pass-through between the exchange rate and the consumer price index stands at 29 percent, which is about the same size in all the studies quoted in the literature review, and secondly, the pass-through is immediate and is expressed most clearly in the quarter when the depreciation occurred, and in a few cases in the following quarter.

Table 5: Pass-through obtained from the estimation of equation (3)

			Pass-through (%) in quarter:									
Series no.	Definition	Weight in CPI	0	1	2	3	4	5	6	7	Cummulative pass-through for component (%)	Component's contribution to overall pass-through (%)
1	Tradable veg. and fruit	10.6	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.1
2	Nontradable veg. and fruit	22.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Nontradable controlled food	32.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Nontradable non-controlled food	41.8	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	0.2
5	Controlled tradable food	8.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	0.1
6	Tradable non-controlled food	56.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Housing	216.2	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.0	15.1
8	Gas	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Municipal taxes	23.3	19.7	0.0	-19.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
10	Electricity	27.5	20.6	47.4	0.0	0.0	0.0	0.0	0.0	0.0	68.0	1.9
11	Water	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	Household maintenance	37.7	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.3
13	Fuel for household use	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Furniture and household equipment	42.6	26.3	16.7	0.0	0.0	0.0	0.0	0.0	0.0	42.9	1.8
15	Nontradable clothing and footwear	0.9	7.5	9.7	0.0	0.0	0.0	0.0	0.0	0.0	17.2	0.0
16	Tradable clothing and footwear	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	Books and study materials	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	Controlled education	36.8	15.3	10.9	0.0	0.0	0.0	0.0	0.0	0.0	26.2	1.0
19	Non-controlled education, culture and entertainment	50.9	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.6	1.5
20	Tradable culture and education	38.1	23.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0	34.7	1.3
21	HMO services	12.1	28.3	0.0	-21.0	0.0	0.0	0.0	0.0	0.0	7.3	0.1
22	Private medicine	22.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.2
23	Medication and medical equipment	16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	Public transport	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	Communications services	39.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	Driving lessons, car rental etc.	3.8	0.0	-15.7	-23.2	8.4	6.7	0.0	0.0	0.0	-23.7	-0.1
27	Car and maintenance	87.3	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	1.1
28	Overseas travel	36.3	63.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.7	2.3
29	Nontradable miscellaneous	12.1	12.0	-11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
30	Tradable miscellaneous	31.8	18.1	17.1	0.0	0.0	0.0	0.0	0.0	0.0	35.2	1.1
31	Fuel and oils for vehicles	34.0	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.0	1.0
	Total pass-through in quarter		26.6	3.2	-0.8	0.0	0.0	0.0	0.0	0.0		**29.0**

We must stress that in a more general model which takes into account all the repetitive influences which could occur following a change in the exchange rate, the estimation of the overall pass-through from the exchange rate to prices is more complex: the rise in prices in each item, separately, eventually affects the rise in prices overall, and therefore there could be a repetitive effect on some of the sub-clauses; also the rise in prices could bring about a rise in wages, could affect the

exchange rate and the monetary interest rate through the reaction function of the Bank of Israel, and a change in the interest rate will of course affect in turn the exchange rate and prices. When relating to the complete mechanism of pass-through all these channels must be taken into account, though such a research approach is very cumbersome in this type of work, where the emphasis is on the disaggregation of the link between the exchange rate and prices. In any case, it seems the point at which our chosen approach of estimation has stopped describes satisfactorily the principle of the process.

B. The Housing Item

Half of the pass-through stems from the housing item. To understand this outcome, we will detail first of all the usual method of calculation of the housing index by the CBS. The housing item in the index is made up of three components; owner-occupied housing (with a weighting of 166.9 of the CPI), rent (42.7) and other housing expenses (6.6) which includes brokers' fees, drawing up of contracts, insurance etc. The index of rent is calculated based on reports received from several thousand apartment tenants (see Table 6), who report to the CBS the rent as quoted in their contracts, the currency that the sum is quoted, the system of indexation, and the period of the contract. Based on the period of the contract and the indexation method reported, the CBS updates the rent of that participating tenant. So for example, if one sample observation reported in January of a one-year rental contract signed for X dollars a month rent, and that the rent is indexed to the rate of the dollar, so in February and in every month up to the following January, the CBS will not contact this observation, but will simply update the rent according to the changes in the exchange rate.[32] In such apartments, if so, the pass-through from the exchange rate to the rental price index is 100 percent for the period of the rental contract. As can be seen from the data in Table 6, more than 90 percent of the housing tenants in the sample reported rental contracts indexed to the rate of the dollar, though over recent years there has been a slow reduction in the rate of dollar-quoted contracts.

Table 6: Various indicators of the CBS' rental sample[33]

Year	Number of observations	Percentage of contracts indexed to the rate of the dollar	Percentage of contracts quoted in dollars	Percentage of contracts signed for one year[34]
2000	3,547	97.21	97.66	90.88
2001	4,443	97.37	97.61	90.45
2002	6,109	95.53	96.37	89.96
2003	7,738	92.72	93.79	89.16
2004	9,264	89.92	91.28	90.41

[32] The exchange rate used to set the index is the average rate of the past two months.
[33] We are indebted to the price department workers at the CBS for these data.
[34] About 5 percent of the contracts are for a longer period, and about 5 percent are for a shorter period.

The owner-occupied housing item was calculated up to 1999 using a complex formula, which took into account the price of the housing, depreciation expenses and interest rate expenses on housing. In 1999, this method of calculation was changed and from 1999, the index has been calculated according to the monthly change in prices for new and renewed house rental contracts, based on the same sample used for the rental housing item. If at the time of renewing a contract there is no change in the dollar rent as quoted in the contract, then the change in shekel terms will be the same––for those apartments where the rent is quoted in foreign currency—as the rate of change in the exchange rate.

Given the nature of rental contracts and the method of calculation of the owner-occupied housing index, the pass-through from the exchange rate to the price of housing, both rented and owner occupied, is very high. Setting rental contracts in foreign currency creates almost total pass-through in the short term, also due to the fact that rental contracts are generally written for one year, a usual characteristic of rental housing markets. Calculating the owner-occupied housing index based on the prices latent in the new and renewed rental contracts is a result of lengthy thought and much discussion over many years[35] and answers a range of factors. Still, the fact is that this method of calculation strengthens the pass-through from the exchange rate to the index, assuming conditions of demand and supply in the rental market do not bring rapid changes in the dollar price, that is, that a change in the exchange rate in the absence of shocks to the demand or supply of apartments will not bring about a change in dollar rent in the short term which will keep the shekel price unchanged. In any case, over the period of estimation two factors were apparently at work which affected the development of the pass-through in opposing directions: the rate of dollar contracts, on one side, fell slowly, as mentioned, acting to lower pass-through; while on the other side the new method of calculation of the owner-occupied housing index has increased the pass-through since 1999.

It can be understood from the above that the pass-through in the housing item, that constitutes half of the pass-through in the consumer price index, is a clear result of the dollarization in the housing market in Israel. It is difficult to think today of the economic logic in indexing rent to the exchange rate. In recent years the exchange rate has been volatile and followed no clear trend, and more than it supplies defense against changes in the value of the local currency, it constitutes a source of volatility of income for landlords and of expenses for tenants. Moreover, professionals in this field suggest that the fact that the rental market is "dollarized" is but one part of a vicious circle which rolls onto the new housing market. Even if the Consumer Protection Law formally obliges prices to be presented in shekels, the entire housing market continues to "think" in dollars, and this radiates to the deals in this sector and others related to it. In light of the recognized effect of the housing item on the index and on its volatility, and also in light of the fact that the rise in prices for services for

[35] For a comprehensive study of this subject, as well as details of relevant literature, see Schiffer (2001).

owner-occupied housing is different in its nature[36] from the rise in prices of other items in the index, there are those that suggest this item be ignored when considering the setting of monetary policy.[37]

C. Tradables and Nontradables, Supervised and Controlled

Of the 12 series of tradable goods and services, in eight of them we obtained a positive, significant pass-through from the exchange rate to prices. The four tradable series that did not register such pass-through were: tradable non-controlled food (series 6), fuel for household use (13), tradable clothing and footwear (16) and medication and medical equipment (23). The most prominent result in this context is the inability of the equation to locate the pass-through, that we know for sure exists, between the exchange rate and the prices of oil and diesel for household use. However when we artificially build a series of world oil prices multiplied by the exchange rate (that is the global price of oil in shekels) the series we obtain is highly attuned to series 13 above. Our assumption is that this inability to locate a pass-through stems from the very high volatility of world prices relative to that of the exchange rate, which makes it difficult for the coefficient of the exchange rate in the regression to catch the effect of the change in the rate. The identical problem is described in Leung (2003). This problem does not exist in series 31 (fuels and oils for vehicles) apparently because the prices of oil for vehicles is supervised up to the point of sale at gas stations, unlike the prices of oil for household use which are supervised only up to the Oil Refineries' gates. The pass-through estimated for series 31 is slightly lower than that calculated manually in Part 3 of this paper according to the data from the Ministry of National Infrastructure, which is expected in light of the fact that global oil prices were lower in the past.

Other than the housing item as described above, there are another 13 nontradable items (out of 19 overall) which registered a pass-through from the exchange rate. Even if an economic rationale cannot be given for these results in all cases, overall this finding does point to the economy being highly influenced by the prices of tradable goods and raw materials, as well as to the existence of dollarization at a no small level in Israel. So for example the pass-through in electricity (series 10) is expected and known, and arises of course from the high dependence of electricity prices on imported raw materials, but it also stems from the arrangement of tariffs for the Israel Electric Corporation with the Public Utility Authority - Electricity. The pass-through for non-controlled education, culture and entertainment (series 19) stems apparently from the vacation and recuperation item, which is included in this series, as well as from the parties and functions item, where according to the CBS sample, most of the prices in it are indexed to the exchange rate, even if they are formally written in shekels. In the items for municipal taxes (9), HMO services (21), and driving lessons and car rental etc. (26) there is a strange phenomenon of a positive and negative pass-through which cancel each other out over time, where the negative

[36] Because the house owner is also the service provider, and therefore is not affected by the price increase.

[37] For a review of the considerations in choosing an index that the inflation target could be directed to, see for example Amir and Ribon (1999).

pass-through cannot be explained economically, and possibly could testify to a specification problem of the equations. However one must note that generally negative observations of the IRF are found on the border of significance. The nontradable miscellaneous item (30) suffers a similar problem, although this item includes legal services, which are mostly quoted in foreign currency, which should explain the positive part of the significant pass-through.

When we try to locate the effect of price regulation in Israel on pass-through, three examples stand out: the price of oil, electricity and controlled, tradable food (series 5). The highest pass-through among these three (and the highest among all the items except for housing) is for electricity, despite the considerable local costs involved in the production of this service.

D. The Effect of Aggregate Demand in the Economy on Pass-through

The state of demand in the economy might affect the level of pass-through between the exchange rate and prices. Studies that covered this topic in Israel took into account only the effect of the state of the economy on pass-through at a time of depreciation, so we can assume that the pass-through will be weaker in times of recession than in times of economic growth. The sample period in this research included times of appreciation of the exchange rate, which obliges a test of the link between the state of activity in the economy and pass-through. In effect, as we claimed in the theoretical review, the relationship between the state of the economy and the strength of the pass-through is supposed to be the opposite in times of appreciation relative to times of depreciation. We can show this in the following table:

Table 7: The expected relationship between direction of change in exchange rate, state of the economy, and the strength of pass-through

		Recession	Economic growth
depreciation	Strength of pass-through	weak	strong
	Direction of pass-through	Raises prices	Raises prices
appreciation	Strength of pass-through	strong	weak
	Direction of pass-through	Lowers prices	Lowers prices

In order to check these assumptions, we created dummy variables for periods of depreciation and appreciation, and changed equation (3) thus:

$$dP_{it} = a_i + \sum_{j=1}^{k} \alpha_{ij} dP_{i,t-j} + \sum_{j=0}^{k} \beta_{ij} dUSD_{t-j} + \sum_{j=0}^{k} \gamma_{ij} dPW_{i,t-j} + \sum_{j=1}^{k} \theta_{ij} dEXCLP_{i,t-j} + \delta_{1i}\left(U \cdot dUSD_0 \cdot D_{DEV}\right) + \delta_{2i}\left(U \cdot dUSD_0 \cdot D_{APP}\right) + \varepsilon_{it} \quad (4)$$

where:

$$D_{DEV} = \begin{Bmatrix} 1 & if & dUSD > 0 \\ 0 & otherwise & \end{Bmatrix}, \quad D_{APP} = \begin{Bmatrix} 1 & if & dUSD < 0 \\ 0 & otherwise & \end{Bmatrix}$$

U is the difference between the actual rate of unemployment and the average rate of unemployment in the sample period.

In order to explain the change in this equation, make the following assumptions:

$$dusd = 1\% \quad or \quad -1\%$$
$$U = 1\% \quad or \quad -1\%$$
$$\beta_{i0} = 1 \quad \delta_1 = -0.2 \quad \delta_2 = 0.2$$

Let's concentrate only on the part of equation (4) that is relevant to this argument:

$$dp_{i,t} = \beta_{i0} dusd + \delta_1 \left(U \cdot dUSD_0 \cdot D_{DEV}\right) + \delta_2 \left(U \cdot dUSD_0 \cdot D_{APP}\right) \quad (5)$$

And let us also assume, for simplicity, that the change in each of the other variables in equation (4) that do not appear in equation (5) are equal to zero, as is the constant.

The point of reference is a state of depreciation (or appreciation) with an average rate of unemployment, and then the pass-through is complete, prices rise (or fall) by 1 percent, that is a change in prices of 1.2 percent constitutes a relatively strong pass-through, and a change of 0.8 percent constitutes a weak pass-through. The change in prices obtained in each of the four possible situations of unemployment that are not the average rate is as follows:

In the case of depreciation (δ_1=-0.2), times of growth:

$$dp = 1 \cdot 1 + (-0.2)(-1) \cdot 1 \cdot 1 + 0 = 1.2$$

In the case of depreciation (δ_1=-0.2), times of recession:

$$dp = 1 \cdot 1 + (-0.2) \cdot 1 \cdot 1 \cdot 1 + 0 = 0.8$$

In the case of appreciation (δ_2=0.2), times of growth:

$$dp = 1 \cdot (-1) + 0 + 0.2 \cdot (-1) \cdot (-1) \cdot 1 = -0.8$$

In the case of appreciation (δ_2=0.2), times of recession:

$$dp = 1 \cdot (-1) + 0 + 0.2 \cdot (1) \cdot (-1) \cdot 1 = -1.2$$

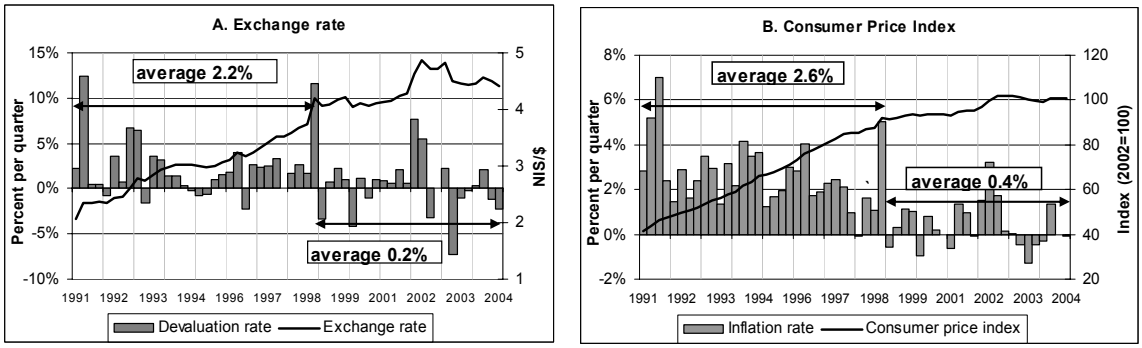
That is, if we obtain from our estimation $\delta_1<0$ then indeed in a situation of depreciation the pass-through reacts to the state of the economy as expected, and likewise if we obtain $\delta_2>0$ then in a state of appreciation the pass-through reacts to the state of the economy as expected.

The results of our estimation of equation (4) are detailed in Appendix 6. First, in none of the equations is the coefficient δ_2 significant, that is the effect of the appreciation on pass-through in Israel is not dependent on the state of aggregate demand in the economy. In eight of the equations, we obtained a significant negative result for the coefficient δ_1, that is there was some effect of the state of demand in the economy on the effect of depreciation on pass-through, though this effect was obtained in small items and not those of great importance. In one equation (18) the coefficient δ_1 had a significant and positive sign, contrary to expectations.

E. The Variation in Pass-Through over Time

The sample period in this research could be characterized into two disparate periods. In the years 1991–1998 the exchange rate fluctuated in a clear, certain trend of consistent nominal depreciation. From 1999 the exchange rate fluctuated with no clear trend, and contrary to the past, sharp depreciations did not necessarily bring with them the consolidation of the exchange rate at a high level, and they could be wiped out by sharp appreciations. These periods characterized also the drop in inflation to a low level, consistent with the inflation levels in developed countries (Figure 2).

Figure 2: The Exchange Rate and Consumer Price Index in the Sample Periods: Quarterly Rates and Changes in Levels



As detailed in the theoretical review, one can expect that in times where the exchange rate has no clear trend, and the inflation rate is relatively stable and low and that the public believes in the resolve of the central bank to maintain the inflation target, then the coefficient of the pass-through from the exchange rate to the consumer price index will be lower. The fall of the pass-through in recent years has indeed been found by Bufman and Leiderman (2001) and by Edwards (2006). To test this assumption here we estimated equation (3) afresh where we added a dummy variable for the period 1999:1–2004:4, and multiplied it as an interaction variable with the rate of depreciation, so that the value of the dummy variable expresses the change in the direct pass-through from the exchange rate to the explanatory variable between the

periods. The dummy variable though does not necessarily catch all the possible effects of the pass-through during the sample period, and it would have been better to have estimated all the equations separately for the two periods. But such an estimation is problematic because of the relatively short sample period of this research. The approach taken here is similar to that taken by Edwards, and is shown in equation (6):

$$dP_{it} = a_i + \sum_{j=1}^{k} \alpha_{ij} dP_{i,t-j} + \sum_{j=0}^{k} \beta_{ij} dUSD_{t-j} + \sum_{j=0}^{k} \gamma_{ij} dPW_{i,t-j} + \sum_{j=1}^{k} \theta_{ij} dEXCLP_{i,t-j} + \sum_{j=0}^{1} \delta_{3i} \left(dUSD_{t-j} \cdot D_{99-04} \right) + \varepsilon_{it} \quad (6)$$

where D_{99-04} is a dummy variable that is equal to 1 in the period 1999:1–2004:4.

After the estimation, we ran the calculating process of the Impulse Response Function and the confidence interval again, twice: once for the dummy variable at zero, that is simulating the first part of the sample period, and the second time with the dummy variable at 1, simulating the second period. The results of the equation are shown in Appendix 8.

As we can see, the pass-through in the first period is indeed higher than in the second, with most of the difference stemming from food [nontradable and controlled (3) and tradable and non-controlled (6)], furniture and household equipment (14), clothing and footwear (16), non-controlled education culture and entertainment (19), and tradable culture and entertainment (20). In contrast, the pass-through in housing (7) was higher in the second period, as a result of the change in the method of calculation of the owner-occupied housing index.

Table 8: Results of Examining the Variability of the Pass-through between 1991–1998 and 1999–2004

			Original estimation (no dummy)		Dummy equals zero (simulating first period)		Dummy equals one (simulating second period)	
Series no.	Definition	Weight in CPI	Cummulative pass-through for component (%)	Component's contribution to overall pass-through (%)	Cummulative pass-through for component (%)	Component's contribution to overall pass-through (%)	Cummulative pass-through for component (%)	Component's contribution to overall pass-through (%)
1	Tradable veg. and fruit	10.6	9.2	0.1	30.2	0.3	10.1	0.1
2	Nontradable veg. and fruit	22.6	0.0	0.0	0.0	0.0	0.0	0.0
3	Nontradable controlled food	32.7	0.0	0.0	17.7	0.6	-10.1	-0.3
4	Nontradable non-controlled food	41.8	5.6	0.2	10.5	0.4	-0.4	0.0
5	Controlled tradable food	8.1	14.6	0.1	23.8	0.2	3.9	0.0
6	Tradable non-controlled food	56.7	0.0	0.0	23.7	1.3	-8.3	-0.5
7	Housing	216.2	70.0	15.1	67.9	14.7	72.7	15.7
8	Gas	4.1	0.0	0.0	0.0	0.0	0.0	0.0
9	Municipal taxes	23.3	0.7	0.0	8.6	0.2	-10.3	-0.2
10	Electricity	27.5	68.0	1.9	67.6	1.9	68.6	1.9
11	Water	9.7	0.0	0.0	0.0	0.0	0.0	0.0
12	Household maintenance	37.7	8.2	0.3	11.6	0.4	3.6	0.1
13	Fuel for household use	1.5	0.0	0.0	0.0	0.0	0.0	0.0
14	Furniture and household equipment	42.6	42.9	1.8	62.4	2.7	18.0	0.8
15	Nontradable clothing and footwear	0.9	17.2	0.0	17.4	0.0	9.5	0.0
16	Tradable clothing and footwear	29.0	0.0	0.0	21.2	0.6	-11.9	-0.3
17	Books and study materials	2.8	0.0	0.0	9.6	0.0	1.1	0.0
18	Controlled education	36.8	26.2	1.0	22.2	0.8	32.9	1.2
19	Non-controlled education, culture and entertainment	50.9	28.6	1.5	38.5	2.0	16.9	0.9
20	Tradable culture and education	38.1	34.7	1.3	47.4	1.8	17.1	0.7
21	HMO services	12.1	7.3	0.1	19.3	0.2	-20.2	-0.2
22	Private medicine	22.0	7.9	0.2	11.5	0.3	3.5	0.1
23	Medication and medical equipment	16.5	0.0	0.0	0.0	0.0	0.0	0.0
24	Public transport	10.7	0.0	0.0	0.0	0.0	0.0	0.0
25	Communications services	39.8	0.0	0.0	0.0	0.0	0.0	0.0
26	Driving lessons, car rental etc.	3.8	-23.7	-0.1	-25.4	-0.1	-30.5	-0.1
27	Car and maintenance	87.3	12.4	1.1	0.0	0.0	0.0	0.0
28	Overseas travel	36.3	63.7	2.3	65.3	2.4	60.6	2.2
29	Nontradable miscellaneous	12.1	0.6	0.0	3.1	0.0	-2.6	0.0
30	Tradable miscellaneous	31.8	35.2	1.1	44.8	1.4	22.9	0.7
31	Fuel and oils for vehicles	34.0	29.0	1.0	31.3	1.1	25.0	0.8
				29.0		**33.2**		**23.5**

VI. CONCLUSION

In this study an attempt was made, as far as is known for the first time in Israel, to estimate the pass-through between the exchange rate and the consumer price index over several components. The estimation was made by a system of independent equations, where each equation took into account, in addition to the exchange rate, variables that could influence the change in the price of a good or service that the equation was estimating. In addition, the time lags of the explained variable and the explanatory variables made it possible to express the time structure of the pass-through. The finding of the overall pass-through, at a cumulative rate of 29 percent, is similar to that found in earlier studies in Israel in the past decade, and furthermore it was found that most of the pass-through occurred in the quarter when the change in the exchange rate took place. In order to check the assumption that the pass-through fell in recent years following the stabilization of the exchange rate and the drop in inflation to levels prevalent in developed countries, a distinction was made between the period 1991–1998 and 1999–2004 by using a dummy variable, and indeed the pass-through for 1999–2004 was found to be lower than in the period 1991–1998. The relationship between the level of activity in the economy and the pass-through was also examined using a dummy variable, while distinguishing between periods of depreciation—when economic growth is expected to increase pass-through while recession is expected to diminish it—and periods of appreciation—when a recession is actually expected to increase the pass-through and growth is meant to weaken it. The conclusion is that in times of depreciation there is an insignificant effect of the state of economic activity on the pass-through, while this effect is not found at all in times of appreciation.

As expected, the pass-through in Israel was found to be present not just in tradable goods or goods heavily dependent on imported raw materials, but also in many nontradable goods and services. The dollarization that still exists in Israel has a great influence on pass-through between the exchange rate and the CPI. Most of the influence is expressed in the housing item, as a result of the widespread dollarization in the rental housing market in Israel, as well as due to the method of calculation of the owner-occupied housing component of the price index. Dollarization is expressed also in other items, some of them tradable or with a degree of orientation to abroad, such as oil, electricity, travel overseas, and some of them clearly nontradable, such as parties and functions and legal services.

From the point of view of macroeconomic policies, the reduction of the pass-through is important, particularly in nontradable goods and services, in order to weaken the short-term relationship between the exchange rate and prices, a link that increases the volatility of inflation and of the monetary policy derived from it. The reduction of pass-through in the nontradable sector will reduce the level of rigidity of the short-term real exchange rate, allowing it to change according to shocks in the economy, and therefore allowing the necessary adjustment in production and consumption following such shocks.

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APPENDIX 1: MECHANISM FOR SETTING THE PRICES OF FUEL SUPERVISED BY THE MINISTRY OF ENERGY AND NATIONAL INFRASTRUCTURE

The prices of fuels sold at the Oil Refineries' gates are set once a month by the Ministry of Energy and National Infrastructure. The prices are set according to the going oil prices at the Italian port of Genova Lavera, over the last five business days of the month. This price, denoted in dollars, is then multiplied by the sell transfers exchange rate at Leumi Bank to convert it into the Oil Refineries rate (known locally as the Bazan rate, based on the Hebrew acronym for Oil Refineries). The Oil Refineries rate constitutes but a small part of the final consumer price given that on top of this price are added excise tax, marketing margins of the fuel companies and VAT. For example,[38] in May 2006 the price abroad of a ton of octane 95 oil was $712.40 and the exchange rate was NIS 4.57 to the dollar, so that the price of a ton of octane 95 oil was NIS 3,258.30 in local currency. At this stage the price must be adjusted to quantity, which is essential as the correlation between weight and volume of oil is not constant and depends on various factors such as difference in temperature. After this adjustment has been made, we obtain an Oil Refineries gate price (including a number of extras) of NIS 2,488.50 per 1,000 liters, to which is added excise tax of NIS 2,254.90, marketing margin of NIS 586.99 and VAT of NIS 879.53. This brings the official price to NIS 6,210 per 1,000 liters or NIS 6.21 per liter. So, *ceteris paribus*, the change in the exchange rate in May 2006 of 1 percent would have brought about a 0.47 percent change in the consumer price of oil. One must note that in earlier times, the pass-through from the exchange rate was lower as the world oil prices were lower while some of the other components of the local oil price were fixed.

[38] Source of data, the website of the Ministry of Energy and National Infrastructure.

APPENDIX 2: RESULTS OF UNIT ROOT TESTING

Table 9: Unit root tests

	Series	Signif. Level	Series	Signif. Level	Series	Signif. Level	Series	Signif. Level
Tradable veg. and fruit	DP_1	0.20%	DPW_1	0.00%	$DEXCLP_1$	0.64%	DUSD	0.00%
Nontradable veg. and fruit	DP_2	0.00%	DPW_2	0.01%	$DEXCLP_2$	0.68%		
Nontradable controlled food	DP_3	0.87%	DPW_3	0.01%	$DEXCLP_3$	0.57%		
Nontradable non-controlled food	DP_4	0.79%	DPW_4	0.01%	$DEXCLP_4$	0.60%		
Controlled tradable food	DP_5	0.01%	DPW_5	0.00%	$DEXCLP_5$	0.65%		
Tradable non-controlled food	DP_6	0.01%	DPW_6	0.00%	$DEXCLP_6$	0.57%		
Housing	DP_7	0.00%	DPW_7	10.92%	$DEXCLP_7$	0.37%		
Gas	DP_8	1.44%	DPW_8	0.35%	$DEXCLP_8$	0.66%		
Municipal taxes	DP_9	3.46%	DPW_9	10.92%	$DEXCLP_9$	0.68%		
Electricity	DP_{10}	0.00%	DPW_{10}	0.00%	$DEXCLP_{10}$	0.82%		
Water	DP_{11}	0.03%	DPW_{11}	0.00%	$DEXCLP_{11}$	0.63%		
Household maintenance	DP_{12}	0.05%	DPW_{12}	0.00%	$DEXCLP_{12}$	0.64%		
Fuel for household use	DP_{13}	0.00%	DPW_{13}	0.00%	$DEXCLP_{13}$	0.71%		
Furniture and household equipment	DP_{14}	1.07%	DPW_{14}	0.00%	$DEXCLP_{14}$	0.58%		
Nontradable clothing and footwear	DP_{15}	83.35%	DPW_{15}	10.92%	$DEXCLP_{15}$	0.66%		
Tradable clothing and footwear	DP_{16}	0.00%	DPW_{16}	0.00%	$DEXCLP_{16}$	0.59%		
Books and study materials	DP_{17}	9.58%	DPW_{17}	0.43%	$DEXCLP_{17}$	0.65%		
Controlled education	DP_{18}	41.07%	DPW_{18}	10.92%	$DEXCLP_{18}$	0.56%		
Non-controlled education, culture and entertainment	DP_{19}	64.43%	DPW_{19}	10.92%	$DEXCLP_{19}$	0.57%		
Tradable culture and education	DP_{20}	2.48%	DPW_{20}	0.00%	$DEXCLP_{20}$	0.62%		
HMO services	DP_{21}	0.49%	DPW_{21}	10.92%	$DEXCLP_{21}$	0.63%		
Private medicine	DP_{22}	92.45%	DPW_{22}	10.92%	$DEXCLP_{22}$	0.58%		
Medication and medical equipment	DP_{23}	0.00%	DPW_{23}	0.00%	$DEXCLP_{23}$	0.63%		
Public transport	DP_{24}	61.42%	DPW_{24}	0.00%	$DEXCLP_{24}$	0.60%		
Communications services	DP_{25}	0.75%	DPW_{25}	10.92%	$DEXCLP_{25}$	0.39%		
Driving lessons, car rental etc.	DP_{26}	0.08%	DPW_{26}	10.92%	$DEXCLP_{26}$	0.65%		
Car and maintenance	DP_{27}	0.06%	DPW_{27}	0.00%	$DEXCLP_{27}$	0.43%		
Overseas travel	DP_{28}	0.00%	DPW_{28}	0.00%	$DEXCLP_{28}$	0.80%		
Nontradable miscellaneous	DP_{29}	2.67%	DPW_{29}	10.92%	$DEXCLP_{29}$	0.63%		
Tradable miscellaneous	DP_{30}	0.01%	DPW_{30}	0.00%	$DEXCLP_{30}$	0.64%		
Fuel and oils for vehicles	DP_{31}	0.00%	DPW_{31}	0.00%	$DEXCLP_{31}$	0.99%		

The value shown in Table 9 is the level of confidence at which we can reject the null hypothesis that the series is characterized by a unit root. In all the tests the number of time lags was set by the SIC criteria. Note that some of the DPW series repeat themselves.

APPENDIX 3: ENDOGENEITY TESTS

The Hausman test[39] for endogeneity was carried out in the following stages:

A. We estimated equation (A1) below which is a modification of equation (1), where the left hand variable is the variable suspected of endogeneity (the rate of simultaneous depreciation of the exchange rate), and we added instruments to the equation which are correlated with the exchange rate but not with the original left hand variable—the change in prices. We found that it is difficult to think of instruments for the exchange rate that are exogenous to prices. One variable that could be a very good instrument in some of the period is the lower slope of the currency exchange band in dollar terms: this variable is correlated with the depreciation of the exchange rate at a rate of 74 percent in the years 1991–1997, and at a rate of 41 percent over the whole sample period (1991–2004).

$$dUSD_{it} = a_i + \sum_{j=1}^{k} \alpha_i^j dP_{i,t-j} + \sum_{j=1}^{k} \beta_i^j dUSD_{t-j} + \sum_{j=0}^{k} \gamma_i^j dPW_{i,t-j} + d(USDBAND)_t + v_{it} \quad \text{(A1)}$$

where USDBAND is the lower limit of the fluctuation band in dollar terms.

B. The calculated residual from equation 2 is marked as $\hat{v}_i$.

C. Equation (1) was estimated again, with the addition of the residual from equation (2):

$$dP_{it} = a_i + \sum_{j=1}^{k} \alpha_i^j dP_{i,t-j} + \sum_{j=0}^{k} \beta_i^j dUSD_{t-j} + \sum_{j=0}^{k} \gamma_i^j dPW_{i,t-j} + \delta_i \hat{v}_{i,t} + \varepsilon_{it} \quad \text{(A2)}$$

D. If the coefficient δ_i was different from zero at a significance level of at least 5 percent, then we determined that there was a problem of endogeneity, and then we would not be able to estimate equation (1) by the OLS method.

Table 10 shows the confidence levels of the test results. The value in the table notes the significance level at which we may reject the null hypothesis that the coefficient δ_i in equation (A2) is equal to zero, and thus cannot reject the hypothesis that there exists a problem of simultaneity between the change in the exchange rate and the explained variable. We can see that in most of the equations there is no problem of endogeneity, whether with the specifications of equation (1) or equation (3). Only in series 28 (travel abroad) is the absence of endogeneity rejected at less than the 5 percent confidence level for all numbers of time lags and for all specifications.

[39] See Gujarati (1995), pp. 670–671.

Table 10: Testing endogeneity

		Equation (1)			Equation (3)		
		Lags			Lags		
Series		1	2	3	1	2	3
1	Tradable veg. and fruit	46.5%	35.4%	14.1%	29.1%	8.9%	***1.8%***
2	Nontradable veg. and fruit	7.4%	***3.4%***	13.6%	11.9%	12.8%	34.2%
3	Nontradable controlled food	18.4%	14.8%	66.9%	32.3%	15.3%	43.8%
4	Nontradable non-controlled food	94.0%	74.9%	66.4%	94.1%	68.2%	26.9%
5	Controlled tradable food	47.0%	37.5%	22.0%	61.7%	55.2%	22.8%
6	Tradable non-controlled food	46.5%	55.3%	80.3%	37.3%	19.6%	44.4%
7	Housing	***2.4%***	10.9%	11.4%	***2.4%***	9.6%	19.1%
8	Gas	38.0%	18.9%	20.6%	21.5%	21.1%	17.5%
9	Municipal taxes	41.3%	54.1%	31.9%	43.9%	40.4%	11.7%
10	Electricity	18.3%	7.8%	15.0%	13.8%	5.9%	7.5%
11	Water	79.1%	34.9%	48.2%	71.8%	22.8%	26.5%
12	Household maintenance	47.2%	32.5%	35.8%	41.9%	17.4%	8.6%
13	Fuel for household use	23.7%	10.1%	18.4%	39.3%	24.4%	23.6%
14	Furniture and household equipment	66.6%	60.9%	56.9%	40.8%	26.2%	12.5%
15	Nontradable clothing and footwear	36.1%	21.5%	5.2%	47.9%	28.8%	9.7%
16	Tradable clothing and footwear	8.2%	***4.9%***	***1.4%***	9.3%	6.0%	***1.7%***
17	Books and study materials	95.6%	88.1%	67.2%	99.9%	82.9%	62.2%
18	Controlled education	61.1%	53.5%	91.0%	62.7%	53.1%	78.5%
19	Non-controlled education, culture and entertainment	18.4%	10.8%	7.6%	23.0%	12.4%	20.0%
20	Tradable culture and education	29.1%	56.0%	69.4%	15.5%	34.4%	60.0%
21	HMO services	74.4%	83.2%	86.4%	88.7%	89.5%	74.9%
22	Private medicine	59.4%	27.5%	42.3%	96.8%	58.4%	44.7%
23	Medication and medical equipment	67.4%	86.1%	76.5%	84.8%	79.5%	97.9%
24	Public transport	55.7%	11.6%	23.5%	59.3%	16.6%	22.3%
25	Communications services	97.6%	53.8%	64.8%	74.4%	88.6%	96.5%
26	Driving lessons, car rental etc.	96.7%	75.5%	63.3%	66.7%	88.6%	78.6%
27	Car and maintenance	26.4%	21.8%	24.7%	35.2%	27.4%	25.0%
28	Overseas travel	***2.1%***	***3.7%***	***2.2%***	***2.2%***	***2.9%***	***2.8%***
29	Nontradable miscellaneous	68.3%	74.8%	81.4%	25.4%	***4.9%***	21.1%
30	Tradable miscellaneous	68.7%	59.0%	56.5%	82.0%	71.3%	90.5%
31	Fuel and oils for vehicles	54.8%	54.9%	60.4%	64.0%	63.5%	78.4%

APPENDIX 4: RESULTS FROM ESTIMATION OF EQUATION 3.

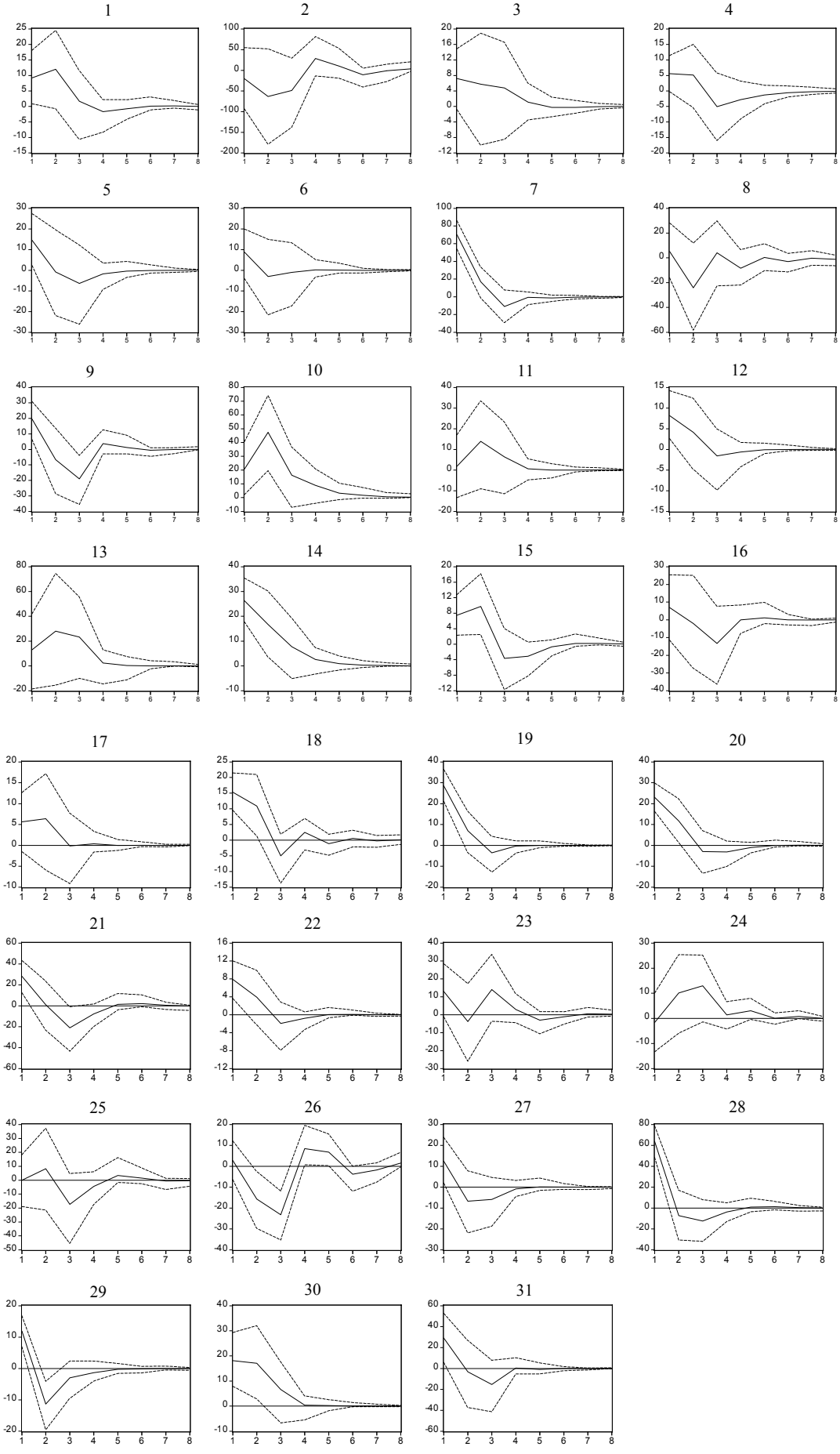
Table 11: Estimation results. For each equation, the estimated coefficient and t value are reported

DP15	DP14	DP13	DP12	DP11	DP10	DP9	DP8	DP7	DP6	DP5	DP4	DP3	DP2	DP1	Left hand var. / Right hand var.
0.0007	-0.0045	0.0301	0.0035	0.0073	0.0009	0.0015	0.0109	0.0004	0.0003	0.0049	0.0024	0.0048	0.0045	0.0016	Constant
0.4	*-1.8*	*2.8*	*2.0*	*1.6*	*0.2*	*0.4*	*1.6*	*0.1*	*0.1*	*1.3*	*1.3*	*1.9*	*0.2*	*0.7*	
0.41	0.27	0.10	0.29	0.13	0.03	-0.16	0.15	0.22	5.2E-04	0.29	0.52	0.42	-0.18	0.29	DP(-1)
2.8	*1.5*	*0.7*	*1.7*	*0.8*	*0.2*	*-0.9*	*1.0*	*1.8*	*0.0*	*1.9*	*3.3*	*2.8*	*-1.3*	*1.8*	
-0.16	0.03	-1.2E-03	-0.04	-0.02	0.18	-0.10	0.37	0.11	-0.06	-0.01	-0.03	-0.15	-0.31	-0.18	DP(-2)
-1.1	*0.2*	*0.0*	*-0.3*	*-0.1*	*1.3*	*-0.6*	*2.5*	*1.0*	*-0.4*	*-0.1*	*-0.2*	*-1.2*	*-2.1*	*-1.2*	
0.07	0.26	0.13	0.08	0.02	0.21	0.20	0.05	0.70	0.09	0.15	0.06	0.07	-0.20	0.09	DUSD
2.4	*5.4*	*0.7*	*2.6*	*0.2*	*1.9*	*2.6*	*0.4*	*7.3*	*1.3*	*1.9*	*1.7*	*1.6*	*-0.5*	*1.9*	
0.07	0.10	0.27	0.02	0.14	0.47	-0.03	-0.25	0.02	-0.03	-0.05	0.02	0.03	-0.67	0.09	DUSD(-1)
1.5	*1.3*	*1.1*	*0.4*	*1.1*	*3.1*	*-0.3*	*-1.4*	*0.1*	*-0.3*	*-0.4*	*0.4*	*0.4*	*-1.0*	*1.3*	
-0.06	0.03	0.20	-0.02	0.05	0.11	-0.18	0.06	-0.22	-0.01	-0.06	-0.08	0.03	-0.67	-1.2E-03	DUSD(-2)
-1.8	*0.5*	*1.1*	*-0.6*	*0.5*	*0.9*	*-2.0*	*0.4*	*-2.0*	*-0.1*	*-0.6*	*-1.9*	*0.6*	*-1.5*	*0.0*	
-3.9E-03	0.10	0.36	0.02	-0.03	0.07	0.08	0.06	0.13	-0.01	-0.11	0.03	0.05	-0.17	-0.06	DPW
0.0	*1.7*	*7.4*	*1.3*	*-1.1*	*2.0*	*0.4*	*1.5*	*0.5*	*-0.1*	*-1.1*	*0.9*	*1.2*	*-0.8*	*-1.6*	
0.08	0.15	0.01	-0.02	0.03	0.07	0.14	-0.03	0.22	0.03	0.10	0.02	0.13	-0.45	-0.02	DPW(-1)
1.0	*2.3*	*0.2*	*-1.1*	*1.1*	*1.9*	*0.7*	*-0.7*	*0.9*	*0.4*	*1.2*	*0.5*	*2.7*	*-2.1*	*-0.7*	
0.06	-0.03	0.04	0.01	0.03	4.6E-03	0.13	-0.04	0.01	0.09	0.11	-0.04	0.01	-0.20	0.02	DPW(-2)
0.7	*-0.6*	*0.6*	*0.7*	*1.0*	*0.1*	*0.6*	*-0.9*	*0.1*	*1.1*	*1.2*	*-1.1*	*0.2*	*-0.8*	*0.7*	
0.07	0.18	-0.66	0.26	-0.04	0.06	0.43	0.41	-0.12	0.60	0.44	0.17	0.20	1.80	0.19	DEXCLP(-1)
0.5	*0.9*	*-1.0*	*1.9*	*-0.1*	*0.1*	*1.0*	*0.9*	*-0.3*	*2.2*	*1.5*	*1.3*	*1.1*	*1.0*	*1.0*	
0.33	0.18	-0.45	0.08	0.23	-0.01	0.65	-0.24	-0.03	0.31	-0.06	0.21	0.12	0.62	0.24	DEXCLP(-2)
2.8	*1.0*	*-0.9*	*0.6*	*0.9*	*0.0*	*2.0*	*-0.7*	*-0.1*	*1.2*	*-0.2*	*1.9*	*0.8*	*0.4*	*0.2*	
0.66	0.61	0.58	0.48	-0.03	0.32	0.34	0.14	0.57	0.33	0.17	0.63	0.48	0.07	0.39	ADJ. R^2

Table 11 (continued)

DP31	DP30	DP29	DP28	DP27	DP26	DP25	DP24	DP23	DP22	DP21	DP20	DP19	DP18	DP17	DP16	Left hand var. / Right hand var.
0.0057	0.0030	0.0049	0.0085	0.0039	0.0009	-0.0061	0.0031	0.0089	0.0042	0.0034	-0.0084	0.0017	0.0001	0.0012	-0.0112	Constant
0.9	*1.1*	*2.8*	*1.9*	*1.4*	*0.3*	*-1.1*	*0.9*	*2.2*	*2.8*	*0.8*	*-3.4*	*0.8*	*1.0*	*0.6*	*-1.9*	
-0.04	-0.02	-0.20	0.42	0.22	-0.13	0.15	-0.09	0.14	0.19	0.36	0.47	0.09	0.28	-0.05	0.01	DP(-1)
-0.3	*-0.1*	*-1.1*	*2.8*	*1.3*	*-0.9*	*1.0*	*-0.6*	*1.0*	*1.3*	*2.4*	*3.0*	*0.5*	*2.0*	*-0.3*	*0.1*	
0.06	0.03	0.17	-0.21	-0.06	-0.34	-0.23	0.25	-0.25	-0.11	-0.20	-0.15	2.8E-03	0.36	0.06	-0.08	DP(-2)
0.4	*0.2*	*1.3*	*-1.3*	*-0.4*	*-2.1*	*-1.6*	*1.9*	*-1.7*	*-0.9*	*-1.3*	*-1.1*	*0.0*	*2.6*	*0.4*	*-0.4*	
0.29	0.18	0.12	0.64	0.12	0.03	-6.6E-04	-0.02	0.13	0.08	0.28	0.23	0.29	0.15	0.06	0.07	DUSD
2.2	*3.1*	*3.7*	*7.1*	*2.1*	*0.5*	*0.0*	*-0.2*	*1.6*	*3.3*	*3.3*	*6.0*	*6.9*	*4.2*	*1.3*	*0.6*	
-0.02	0.17	-0.09	-0.34	-0.09	-0.15	0.08	0.10	-0.06	0.02	-0.09	0.01	0.05	0.07	0.07	-0.02	DUSD(-1)
-0.1	*2.0*	*-2.1*	*-2.1*	*-1.2*	*-1.8*	*0.5*	*1.0*	*-0.5*	*0.6*	*-0.7*	*0.2*	*0.6*	*1.3*	*1.0*	*-0.1*	
-0.17	0.64	-0.07	0.04	-0.04	-0.24	-0.19	0.14	0.18	-0.02	-0.16	-0.05	-0.04	-0.14	-1.4E-03	-0.13	DUSD(-2)
-1.3	*1.0*	*-1.9*	*0.3*	*-0.6*	*-3.7*	*-1.4*	*1.9*	*1.9*	*-0.7*	*-1.6*	*-1.1*	*-0.8*	*-3.4*	*0.0*	*-1.0*	
0.18	0.03	0.03	-0.04	0.12	-0.01	-0.41	0.01	0.10	0.09	-0.06	0.09	0.05	0.31	0.04	0.19	DPW
4.9	*0.5*	*0.4*	*-1.5*	*2.5*	*-0.1*	*-1.4*	*0.6*	*1.2*	*1.3*	*-0.3*	*1.3*	*0.4*	*3.0*	*1.5*	*1.3*	
0.07	0.04	-0.04	0.04	-0.01	0.12	-0.31	0.02	-0.11	0.06	0.40	0.08	0.33	0.24	0.04	0.05	DPW(-1)
1.4	*0.6*	*-0.5*	*1.5*	*-0.2*	*0.8*	*-1.1*	*1.1*	*-1.2*	*1.0*	*1.8*	*1.2*	*2.8*	*2.4*	*1.3*	*0.3*	
5.8E-05	0.06	-0.07	-0.04	0.02	0.16	0.51	0.01	0.15	0.06	-0.03	0.12	0.05	-0.29	0.03	0.04	DPW(-2)
0.0	*0.8*	*-0.9*	*-1.4*	*0.4*	*1.0*	*1.7*	*0.3*	*1.8*	*0.9*	*-0.1*	*1.9*	*0.4*	*-2.6*	*1.0*	*0.3*	
0.89	0.27	0.61	0.12	0.54	0.71	1.02	0.35	0.63	0.33	0.52	0.39	0.10	-0.02	0.24	0.63	DEXCLP(-1)
1.9	*1.2*	*4.8*	*0.4*	*2.4*	*2.8*	*2.2*	*1.4*	*2.1*	*3.4*	*1.4*	*2.6*	*0.6*	*-0.1*	*1.4*	*1.5*	
0.03	0.07	0.27	-0.03	0.09	0.48	-0.21	0.20	-0.33	0.11	0.28	0.11	0.11	0.03	0.27	0.29	DEXCLP(-2)
0.1	*0.3*	*2.1*	*-0.1*	*0.5*	*2.3*	*-0.5*	*0.8*	*-1.3*	*1.1*	*0.9*	*0.8*	*0.8*	*0.3*	*1.8*	*0.8*	
0.41	0.35	0.68	0.55	0.43	0.41	0.22	0.43	0.18	0.77	0.45	0.70	0.69	0.77	0.40	0.07	ADJ. R^2

APPENDIX 5: GRAPHICAL REPRESENTATION OF THE IMPULSE RESPONSE FUNCTIONS: EQUATION (3)



APPENDIX 6: RESULTS OF ESTIMATING EQUATION (4)

Table 12: Results of equation (4)

	Dummy for depreciation periods D_{DEV}		Dummy for appreciation periods D_{APP}	
Equation	Coefficient	Signif. Level	Coefficient	Signif. Level
1	-0.09	0.5%	-0.13	13.0%
2	-0.05	84.2%	-1.03	12.7%
3	-0.05	12.2%	0.09	36.9%
4	-0.05	2.5%	-0.04	50.6%
5	-0.03	53.5%	-0.10	43.6%
6	-0.15	0.1%	-0.20	5.5%
7	-0.04	56.0%	-0.08	64.1%
8	-0.09	27.4%	0.08	65.8%
9	-0.12	2.4%	-0.11	37.4%
10	0.01	92.6%	-0.26	20.7%
11	-0.03	62.4%	-0.12	44.2%
12	-0.08	0.1%	0.02	67.4%
13	-0.09	44.4%	0.21	50.2%
14	-0.11	0.1%	-0.04	58.4%
15	0.00	86.0%	-0.03	65.2%
16	-0.05	53.8%	0.12	54.1%
17	-0.04	14.4%	0.02	77.3%
18	0.05	3.9%	-0.11	7.3%
19	-0.02	57.0%	-0.13	8.1%
20	-0.03	30.8%	-0.09	20.7%
21	-0.10	14.5%	-0.25	12.4%
22	0.00	95.1%	0.01	85.6%
23	0.03	62.8%	-0.01	95.0%
24	0.03	48.0%	0.11	35.3%
25	-0.09	24.0%	-0.08	69.4%
26	0.02	56.9%	-0.18	6.7%
27	-0.04	40.0%	0.10	32.5%
28	-0.07	22.5%	-0.21	18.5%
29	-0.02	33.1%	-0.07	22.5%
30	-0.09	3.9%	0.00	99.2%
31	-0.24	0.7%	-0.11	63.4%