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Relationships between Swedish Producer and Import Prices and the CPI

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Abstract

Relationships between various Swedish producer and import prices and consumer prices (CPI) are investigated. A positive long-term relationship is indicated by economic theory. It may be weakened, however, by differences in the construction of the indexes of producer and import prices compared with the CPI. Moreover, the development of profit margins, labour and capital costs and productivity may affect the development of consumer prices so that this differs from that of producer prices. The study shows that the relationship between aggregated producer and import prices and the CPI is relatively weak, whereas a clear relationship with the CPI is found for price indexes for consumer goods. This is also mirrored in the effects on the CPI. The price effect from consumer goods during a year is considerably stronger than the effects from intermediate and investment goods.

Valuable comments have been received from Per Jansson and Jonas Ahlander.

Contents

1. Introduction

Producer and import prices have risen rapidly in 1994 and 1995. Between the second quarters of 1994 and 1995 the producer price index moved up more than 11 per cent and the import price index more than 9 per cent. In this period the increase in the consumer price index (CPI) stopped at about 3 per cent. It has therefore been feared that the consumer price rise may also accelerate in the future.

The object of this study is the historical relationship between consumer prices and various producer and import prices. The study is arranged as follows. Arguments for and against a clear relationship between producer and import prices and the CPI are discussed briefly in Section 2, together with the results of earlier studies. The purpose of the study and the statistical material are presented in Section 3. The empirical results are reported in Section 4. They include a test for unit roots in the various price indexes and a cointegration test for the existence of a long-term relationship between different indexes for producer and import prices and the CPI. A test for Granger causality has also been made to determine whether changes in the CPI are preceded by changes in different producer and import price indexes. A number of regressions have been performed, moreover, to investigate the extent to which producer and import prices explain the variation in the CPI. The regressions also yield approximate estimates of the consumer price effect from producer and import price movements and whether this effect has changed in recent years. The conclusions from the study are reported in Section 5.

2. Arguments for and against a relationship

Economic theory suggests that producer and import prices are positively related to the CPI. Rising (falling) producer and/or import prices are thus expected be followed by rising (falling) consumer prices. The reasoning behind this is that firms usually set prices in relation to their marginal costs plus a mark-up. For a given profit margin this means that increased costs, for instance in the form of rising producer or import prices, should lead to price increases in subsequent stages of production and distribution.[1] Rising costs and prices in early stages of production should thus spread to subsequent stages and ultimately to the prices paid by final consumers. As a result of both technical and economic factors, however, consumer prices do not necessarily follow the development of producer prices.

(i) Technical factors

The technical factors concern constructional differences between the producer and import price indexes and the CPI. The producer and import prices refer to manufactured goods in every stage prior to the price paid by consumers, whereas the CPI represents consumer prices for services as well as goods. Consumer prices may therefore develop differently from producer prices if, for instance, rising producer or import prices lead to higher consumer prices for goods but this is offset by a downward tendency in consumer prices for services. Another factor that may weaken the relationship has to do with differences in the composition of the producer and import price indexes compared with the CPI. The weights in the system of producer prices are based on data for production and foreign trade, whereas the CPI weights are based on private consumption. A third difference is that indirect taxes and subsidies are included in the measurement of consumer prices but not in producer prices. Consumer prices may thus be altered by changes in indirect taxes or subsidies without there being any direct corresponding effect on producer or import prices.

(ii) Economic factors

In addition to costs for input goods, the variable costs of a firm include outlays for labour and capital. Increased producer prices therefore lead directly to an increase in total costs that is proportionally smaller. In the case where labour and capital costs make up one-half of total variable costs and the other half consists of costs for input goods, by itself a 1 per cent increase in input prices raises total variable costs by only 0.5 per cent.[2] Moreover,

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[1] The size of the profit margin largely depends on the competitive situation and the state of demand. See Haskell et al. (1995).

[2] In Swedish manufacturing, inputs apart from capital and labour account for approximately 75 per cent of total variable costs.

rising producer and import prices may be balanced by falling costs for labour and capital, which is another reason why the development of producer prices may differ from consumer prices.

Production costs are also influenced by productivity. An economic upswing is usually associated with rising prices for input goods and this leads by itself to higher production costs and increased product prices. As a rule, however, an upswing is also associated with increased productivity, which tends to lower unit costs.[3] Rising producer prices may then be offset by stronger productivity gains, leaving production costs and product prices unchanged. Improved productivity in early stages of production should then affect prices in subsequent stages.

Adjustments to profit margins, just like changes in other production costs, can also offset changes in producer prices. With a given profit margin and no change in other production costs, rising producer prices will lead to higher consumer prices. For various reasons, however, firms may choose to lower their profit margins when production costs are rising. One explanation is that firms by this behaviour maximise profits given the demand situation. For one thing, a firm may refrain from increasing its prices on account of the competition or in order to increase its market share. Instead of adjusting prices, moreover, firms may prefer to vary such factors as delivery times, customer services and product quality. The costs involved in adjusting prices may also mean that, to elicit a price change, the change in production costs has to exceed a certain threshold. Contracyclical profit margins can thus explain differences in the development of producer prices compared with consumer prices.

International studies have yielded conflicting accounts of the relationship between producer and consumer prices. For the United States, Clark (1995) reports that the relationship between the producer price index (PPI) and the CPI is relatively weak. A long-term relationship between the corresponding Finnish indexes is reported by Ripatti (1995) but no long-term relationship between wholesale prices and the CPI. The issue of whether profit margins are procyclical or contracyclical has been studied by Haskel, Martin & Small (1995), Bils (1987) and Rotemberg & Woodford (1991) but the empirical findings differ. According to Blinder (1994), a variety of factors lead to price rigidities and thereby to differences in the development of producer compared with consumer prices. Empirical studies accordingly provide no definite indication of how producer and import prices relate to the CPI.

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[3] See Clark (1994).

3. An empirical study - aim and data

Most earlier studies have concentrated on the relationship between the change in various *aggregated* indexes for producer and import prices and the change in CPI. However, all the aggregated price indexes can be broken down into three categories of goods: intermediate, investment and consumer goods. Intermediate goods consist mainly of crude materials and various processed industrial supplies such as, for instance, refinery products, chemicals and pulp. Investment goods are mainly machinery and various means of transportation for services. Consumer goods are finished products on sale to consumers, e.g. food, clothing and household appliances. Simplifying somewhat, the categories can be said to represent different stages in the production process - intermediate goods are used in the production of investment goods, which are used in turn in the production of consumer goods.

This makes it probable that the relationship with the change in CPI varies between the change in the price indexes for the different categories of goods. One hypothesis is that the relationship with the CPI is stronger in the stages of production that are closer to the consumer. According to this hypothesis, the relationship with the change in CPI should be stronger for the change in prices for consumer goods than for the change in prices for intermediate goods. A conceivable explanation is that price increases in an early stage of production are not passed through in full in later stages. This may have to do with price rigidities,[4] for instance, or to time being available to cut other costs so that price increases in an early stage can be offset before the products reach consumers. The aim of this study is therefore to examine the relationship between different indexes of producer and import prices, at an aggregated level as well as for different categories of goods, and the CPI.

The statistical material consists of four price indexes:

- Home sales price index (HS)
- Import price index (IM)
- Domestic supply price index (DS)[5]
- Consumer price index (CPI)

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[4] See Blinder (1994).

[5] This index, which measures prices of goods that are consumed in the domestic economy, is calculated as a weighted combination of the home sales price index (HS) and the import price index (IM) adjusted for tariffs.

The three categories of goods are abbreviated as follows:

INT = intermediate goods
INV = investment goods
CON = consumer goods.

For example, IMINT denotes the price of imported intermediate goods. Monthly series are available for all the price indexes. The aggregated indexes are available from 1975 onwards, while the disaggregated series for the three categories of goods begin with 1980. The classification system for all the price indices is SNI69.[6] Charts showing each of the price indices are presented in Annex 1.

[6] SNI69 is a classification system that divides the Swedish economy into different branches.

4. Empirical results[7]

4.1 Test for unit roots

If a variable is non-stationary (that is, it displays a deterministic or stochastic trend), then assumptions underlying the regression analysis are not fulfilled.[8] In order to ensure that these assumption are fulfilled, the Dickey Fuller test is applied to determine the existence of unit roots.[9] The logarithmic price levels were tested first (level), followed by a test of first differences (1 month).[10] The results are presented in Table 1.

The conclusion from the results is that none of the price levels is stationary. With the exception of the first differences in the home sales prices for intermediate goods, no unit roots were found in the series expressed as first differences. This implies that neither do unit roots occur in the twelfth differences.[11]

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[7] A more detailed presentation of the results will be found i Annex 2.

[8] In regression analysis the stochastic error term is assumed to have a constant mean (zero) as well as a constant variance (and covariance).

[9] The general form of this test involves estimating the equation:

$\Delta X_t = \alpha + \beta X_{t-1} + \sum_{j=1}^{p} \chi_j \Delta X_{t-j} + \delta t + e_t$, where X is the series to be tested and t is a time trend. If β differs significantly from zero, the hypothesis that X has a unit root can be rejected.

[10] All the series studied here are in logarithmic form. This means that the level of consumer prices is defined as $\ln CPI$ and the first differences as $\ln CPI - \ln CPI_{-1}$.

[11] The twelfth difference in the CPI, for example, is defined as $\ln CPI - \ln CPI_{-12}$. The test does not rule out the existence of unit roots in the twelfth differences in the home sales price of intermediate goods.

Table 1. Dickey Fuller test for unit roots†

	Level	*1 month*
HS	-	**
HSINT	-	-
HSINV	-	**
HSCON	-	**
IM	-	**
IMINT	-	**
IMINV	-	**
IMCON	-	**
DS	-	**
DSINT	-	**
DSINV	-	**
DSCON	-	**
CPI	-	**

† The symbol ** denotes that the null hypothesis of a "unit root" can be rejected at the 1 per cent level, while - denotes a probability of less than 5 per cent that the null hypothesis is not rejected.[12]

4.2 Cointegration test

The concern about higher consumer prices as a consequence of the increase in producer and import prices stems in part from the assumption that a long-term relationship exists between these variables. Two tests for cointegration - Johansen's test and the two-step approach of Engle & Granger - have therefore been performed to determine whether a long-term relationship does exist between different producer and import price indexes and the CPI. The main difference between these two approaches is that the short-run dynamics have to be specified for Johansen's test but not for Engle & Granger's.[13]

12 For levels, the null hypothesis in a unit root test is "exactly one unit root" and the alternative hypothesis is "no unit root". For first differences the null hypothesis is "exactly two unit roots" and the alternative hypothesis is the same as above. The table accordingly shows that in a test of first differences the null hypothesis is rejected.

13 In matrix form, Johansen's test is based on the equation: $\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_p \Delta X_{t-p} + \Pi X_{t-p+1} + e_t$. The test entails determining whether or not the Π matrix has full rank; reduced rank implies that the variables are cointegrated. My test assumes a deterministic trend in the data and an intercept in the cointegration equation. In the Engle Granger test, the first step involves

Cointegration is considered to exist if both tests are positive. The results are presented in Table 2.

Table 2. Test for cointegration among producer and import prices and the CPI †

	Johansen	*Engle & Granger*
HS	*	-
HSINT	-	-
HSINV	*	-
HSCON	*	*
IM	*	-
IMINT	-	-
IMINV	*	-
IMCON	*	-
DS	*	-
DSINT	-	-
DSINV	*	-
DSCON	*	*

† The symbol * denotes that the null hypothesis "the series are not cointegrated" can be rejected at the 5 per cent level, while - denotes a probability of less than 5 per cent that the null hypothesis is not rejected.

In most cases the tests gave different results. Whereas Johansen's test shows that most of the series are cointegrated with the CPI, Engle & Granger's test shows that they are not.[14] There are only two series for which both tests show a long-term relationship with the CPI: the consumer goods price indexes for home sales as well as for domestic supply (imports + home sales). This leads to the conclusion that it is only consumer goods prices that covary with the CPI in the long term. This seems natural in that these prices refer to the stage of production and distribution that is closest to the consumer.

4.3 Granger causality

If changes in producer and import prices are to serve as a good indicator of changes in the CPI, it is necessary that the former precede the latter. One

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fitting a regression equation to the data series; this equation contains an intercept but no trend. In the second step, a Dickey Fuller test is performed to determine whether or not the residuals from this regression are stationary. If they are, the series are cointegrated.

[14] The difference is not a consequence of the sensitivity of Johansen's test to the choice of a particular number of time lags.

way of determining whether this is the case is to test for Granger causality.[15] Results from this test of whether changes in producer and import prices precede changes in the CPI are presented in Table 3. The test is done on the first and the twelfth differences.[16]

Table 3. Test for Granger causality†

	1 month	*12 months*
HS	*	-
HSINT	-	*
HSINV	**	-
HSCON	-	*
IM	*	*
IMINT	-	-
IMINV	-	-
IMCON	*	-
DS	**	*
DSINT	-	-
DSINV	-	-
DSCON	**	*

† The symbol * denotes that the null hypothesis "no Granger causality from the producer (import) price to the CPI" can be rejected at the 5 per cent level, ** that the null hypothesis can be rejected at the 1 per cent level, and - denotes a probability of more than 5 per cent that the null hypothesis is rejected.

[15] The following equations are estimated:

$$\Delta p_t = \alpha + \sum_{i=1}^{12} \beta_i \Delta p_{t-i} + \sum_{i=1}^{12} \delta_i \Delta X_{t-i} + e_t$$

and $$\Delta X_t = \phi + \sum_{i=1}^{12} \gamma_i \Delta X_{t-i} + \sum_{i=1}^{12} \eta_i \Delta p_{t-i} + e_t,$$ where p is the CPI and X is a producer or import price index. The test is performed for the first and twelfth differences. A necessary and sufficient condition for the existence of Granger causality between the producer or import price and the CPI without feedback from the CPI to the producer or import price is that some δ_i differs from zero and that all η_i are zero. A 12-month lag is used in order to eliminate seasonal effects.

[16] Given the existence of unit roots and no cointegration, the test for Granger causality should be specified in terms of differences in order to obtain stationarity in the error term. In the event of cointegration, under certain circumstances a test for Granger causality can also be performed between price levels.

The results suggest that it is primarily price changes for consumer goods and in the aggregated indexes that precede changes in the CPI. This applies in particular to import prices and domestic supply. The picture for home sales is less clear-cut; in this case, changes in the CPI are also preceded by price changes for intermediate and investment goods. It is thus concluded that changes in a majority of the producer and import prices precede changes in the CPI. However, this does not tell us whether these producer and import prices contain information of relevance for the future development of the CPI.

4.4 Estimations (OLS)[17]

A number of models have been estimated to determine to what extent the different producer and import prices explain some of the variation in the CPI. The following autoregressive model was estimated first:

$$\Delta p_t = \alpha + \sum_{i=1}^{12} \beta_i \Delta p_{t-i} + e_t \qquad (1)$$

where Δp_t is the first difference in the CPI. Here the development of the CPI is explained solely in terms of its development in earlier periods.[18] The result from this model was then compared with estimations of the model:

$$\Delta p_t = \alpha + \sum_{i=1}^{12} \beta_i \Delta p_{t-i} + \sum_{i=0}^{12} \delta_i \Delta X_{t-i} + e_t \qquad (2)$$

where ΔX_t is the first difference in the different producer and import prices. A comparison of the results for these two models indicates to what extent the inclusion of producer and import prices adds explanatory power.[19] Table 4 shows the explanatory power with equation 2 and, based on an F test, the

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[17] The following diagnostic tests were performed in all the estimations:
- Breusch Godfrey test for autocorrelation
- ARCH LM test for heteroscedasticity
- Jarque Bera test for a normal distribution of the residuals
- CUSUM and CUSUM square tests for parameter stability

[18] The lagged change in CPI will capture the extent of price rigidities in the Swedish economy. Several studies suggests that Swedish prices are rigid. See for example Assarsson (1989).

[19] In the following, X_t is assumed to be weakly exogenous with regard to the δ parameters; this is a sufficient condition for inference.

probability that the producer or the import price does not strengthen the explanatory power compared with equation 1.[20]

Table 4. Explanatory power (R^2) and probability (P)
Per cent

	R^2	*P*
Equation 2:		
HS	0.39	0.000
HSINT*	-	-
HSINV	0.39	0.000
HSCON	0.29	0.021
IM	0.28	0.030
IMINT	0.29	0.125
IMINV	0.31	0.058
IMCON	0.33	0.012
DS	0.35	0.000
DSINT	0.29	0.110
DSINV	0.29	0.148
DSCON	0.41	0.000
Equation 1	0.18	

* The price series for home sales of intermediate goods is not stationary, which means that the parameter estimates will not have an F distribution.

Except in the case of home sales, it is consumer goods prices that are most capable of explaining the variation in the CPI of the different producer and import prices. The inclusion of consumer goods prices for domestic supply more than doubles the explanatory power. This is in line with the finding in Section 4.2 that prices of consumer goods are cointegrated with the CPI. Except in the case of home sales prices for investment goods, a test at the 5 per cent level shows no increase in explanatory power from the inclusion of prices for intermediate or investment goods.[21]

From these estimations one cannot draw any conclusions about the extent to which consumer prices are affected by a change in producer prices. To

[20] Because the time series vary in length, neither the explanatory power nor the level of probability is directly comparable between the variables. The twelfth differences is used in order to eliminate prospective seasonal effects.

[21] With regard to the residuals, the diagnostic tests show that neither autocorrelation nor heteroscedasticity occurs at the 5 per cent level. Moreover, the residuals are normally distributed.

investigate this it is necessary to estimate a model that includes a number of other factors that also affect the CPI. In order to obtain an indication of the magnitude of the effect on consumer prices, the following simple model has therefore been estimated:

$$\Delta p_t = \alpha + \sum_{i=0}^{k} \beta_i \Delta U_{t-i} + \sum_{i=0}^{k} \chi_i \Delta D_{t-i} + \sum_{i=0}^{4} \delta_i \Delta X_{t-i} + DUM + e_t \quad (3)$$

where U stands for unit labour costs (ULC) in the total economy, D is a demand variable, X represents the different producer and import prices and DUM is a dummy variable for tax reforms in the early 1990s.[22] Private consumption and the output gap have both been used as the demand variable. The estimations have been done with quarterly data[23] and all variables except the dummy variable are logarithmic first differences. An approximate indication of the annual price effect is $\sum_{i=0}^{4} \delta_i$. A more stable estimation can be obtained by rewriting equation (3) in the form:

$$\Delta p_t = \alpha + \sum_{i=0}^{k} \beta_i \Delta U_{t-i} + \sum_{i=0}^{k} \chi_i \Delta D_{t-i} + \delta X_t + \sum_{i=0}^{3} \gamma_i \Delta^2 X_{t-i} + DUM + e_t$$

With this equation (3') the annual price effect is given by the value of the coefficient δ.[24] In order to investigate whether producer and import prices add anything to the explanatory power, an equation was estimated with these prices excluded. This model is referred to as (3.1). Table 5 presents the explanatory power (R^2), the probability (P) that producer and import prices do not explain any of the variation in the CPI, and the estimated price effect.

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[22] Private consumption is seasonally adjusted. For effects of the tax reform in the first quarters of 1990 and 1991 the dummy variable has been assigned the value 1, while a value of -1 has been included for the first quarter of 1992 to allow for the cut in VAT on food, etc. Profit margins are assumed to be constant.

[23] Monthly data could not be used because figures for unit labour costs and private consumption are available only on a quarterly basis.

[24] The expression for the price effect in equation (3) can be written:
$\sum_{i=0}^{4} \delta_i = \delta_0 + \delta_1 + \delta_2 + \delta_3 + \delta_4$, which is equivalent to δ in equation (3'). The coefficients in equation (3') can be written: $\gamma_0 = -(\delta_1 + \delta_2 + \delta_3 + \delta_4)$, $\gamma_1 = -(\delta_2 + \delta_3 + \delta_4)$, etc. This demonstrates the linkage between the coefficients in these two equations.

Table 5. Estimation of producer and import price effects on the CPI
Per cent

	R^2	*P*	*Price effect (δ)*
Equation 3':			
HS	0.77	0.000	0.69**
HSINT	-	-	-
HSINV	0.76	0.000	0.48**
HSCON	0.80	0.000	0.67**
IM	0.73	0.000	0.32**
IMINT	0.66	0.001	0.16**
IMINV	0.64	0.011	0.16**
IMCON	0.68	0.000	0.28**
DS	0.80	0.000	0.58**
DSINT	0.66	0.000	0.29**
DSINV	0.68	0.002	0.38**
DSCON	0.83	0.000	0.54**
Equation 3.1	0.65		

** Statistically significant at the 1 per cent level.

With a 5 per cent confidence interval, all the producer and import prices add to the explanatory power compared with model (3.1). The results in Table 5 largely agree with those in Table 4. It is producer and import prices in general and these prices for consumer goods in particular that are most able to explain the variation in the CPI. In these estimations, too, it is consumer goods prices for domestic supply that have the highest explanatory power.[25]

At a disaggregated level, the price effect is greatest for consumer goods and lowest for intermediate goods. In the case of prices for domestic supply, the annual price effect is 50-60 per cent for consumer goods and about 30 per cent for intermediate goods. The lower effect for intermediate goods probably has to do with the circumstance that these items tend to be used as inputs in the production of consumer goods, which means that it takes longer for price increases for intermediate goods to pass through to consumer prices. Consequently there is more time to offset this by cutting costs in other respects. The estimations also show that price changes for consumer

[25] Applying the diagnostic tests to the residuals shows that neither autocorrelation nor heteroscedasticity occurs at the 5 per cent level. The residuals also have a normal distribution.

goods tend to pass through to the CPI in the same or the next quarter, whereas the corresponding lag for intermediate and investment goods may be up to four quarters. This was expected in that intermediate and investment goods are used in early stages of production, while consumer goods are used in the stage that is closest to the consumer. Finally it can be noted that the price effect from imported goods is generally lower than the effect from goods for home sales.

Tests for stability[26] at the 5 per cent level show that the estimations of all parameters, including the price effect (δ), in model 3' are stable over time. Figures for the annual rate of change in the indexes for producer and import prices as well as for the CPI are given in Annex 3.

[26] CUSUM and CUSUM square.

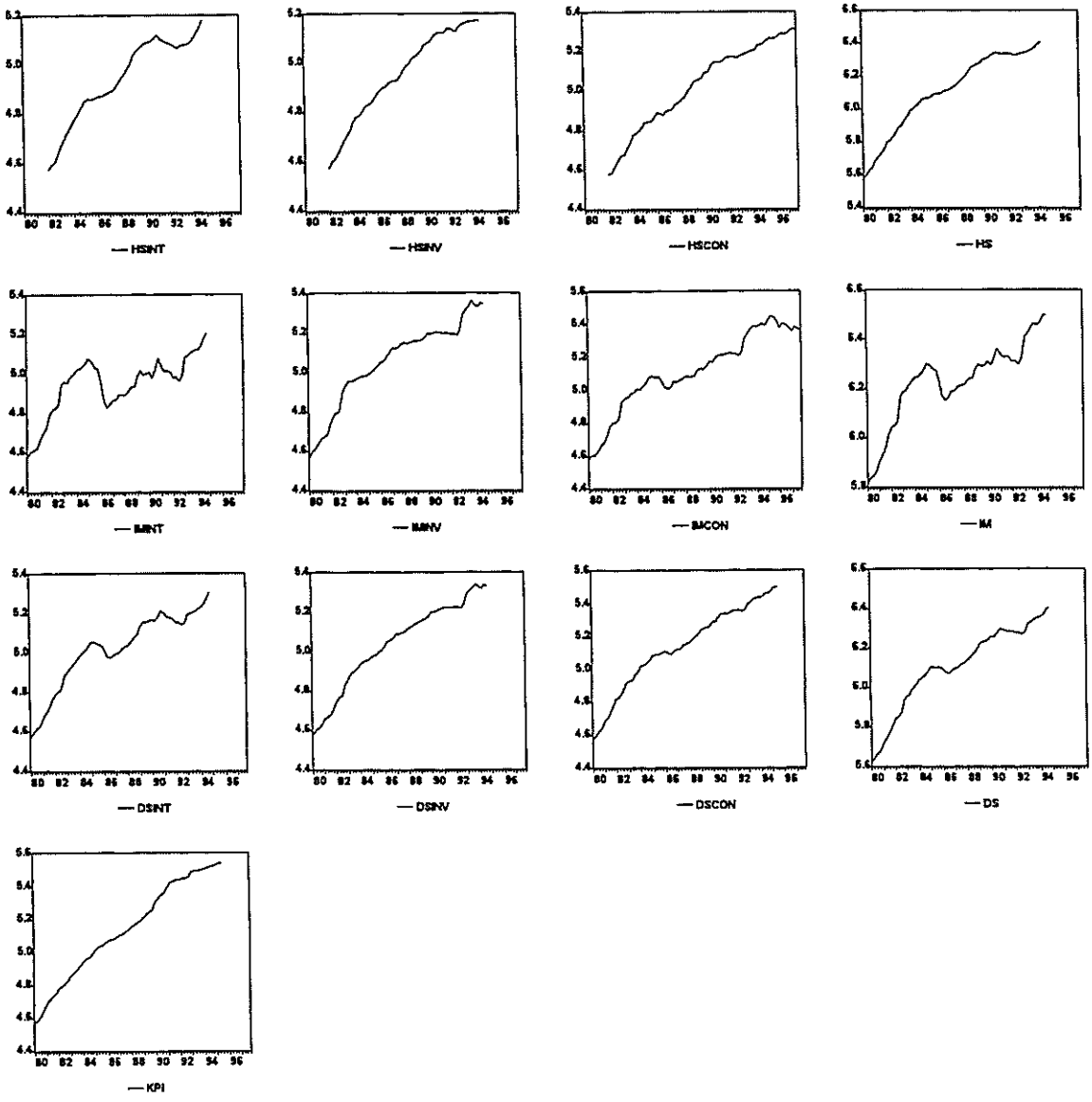
5. Conclusions

The strength of the relationship between producer and import prices and the consumer prices varies to a large extent with the producer or import price that is used. It is prices of consumer goods that can be considered to be the best indicators of changes in the CPI. The price indices for consumer goods in home sales and in domestic supply are cointegrated with the CPI. It is also primarily changes in different prices for consumer goods that have preceded changes in the CPI. Changes in aggregated prices for producer and import prices also precede changes in the CPI. It is also mainly price changes for consumer goods that are most capable of explaining variations in the CPI. The price index for consumer goods in domestic supply consistently shows the clearest relationship with the CPI.

The results suggest that price changes for consumer goods affect the CPI to a greater extent than price changes for intermediate goods. More than 50 per cent of a price increase for consumer goods in domestic supply shows up in the CPI in the course of one year and the price effect is greatest in the same quarter as the change occurs in the producer or import price. Price increases for intermediate goods, on the other hand, pass through to only 30 per cent and in contrast to other prices, the maximum effect on the CPI may be lagged by up to one year.

Annex 1. Charts

Logarithmic price levels



Annex 2. Estimation results

4.1. Test for unit roots

Variable	ADF statistic Level	1-month	Critical value 5%	1%
HS	-2.52	-4.18	-3.44	-4.01
HSINT	-2.38	-1.56	-3.44	-4.02
HSINV	-1.25	-5.96	-3.43	-4.02
HSCON	-2.06	-6.49	-3.44	-4.02
IM	-2.14	-5.75	-3.43	-4.00
IMINT	-2.06	-5.59	-3.44	-4.01
IMINV	-2.29	-5.66	-3.44	-4.01
IMCON	-2.44	-5.53	-3.44	-4.01
DS	-1.18	-6.29	-3.43	-4.00
DSINT	-2.19	-4.30	-3.44	-4.01
DSINV	-1.73	-6.19	-3.44	-4.01
DSCON	-3.13	-5.66	-3.44	-4.01
CPI	-0.36	-6.78	-3.43	-4.00

These data were obtained with a Dickey Fuller test that included both an intercept and a trend for the price levels as well as for the first differences. Since the ADF statistic is larger, in absolute terms, than the critical value, there are no unit roots. The absence of unit roots in the residuals indicates that the series are cointegrated.

4.2. Cointegration test

a) Johansen's test

Variable	Test statistic	Critical value 5%	1%
HS	19.04	15.41	20.04
HSINT	9.28	15.41	20.04
HSINV	19.48	15.41	20.04
HSCON	15.52	15.41	20.04
IM	19.17	15.41	20.04
IMINT	13.45	15.41	20.04
IMINV	19.09	15.41	20.04
IMCON	16.27	15.41	20.04
DS	19.68	15.41	20.04
DSINT	14.01	15.41	20.04
DSINV	16.72	15.41	20.04
DSCON	19.41	15.41	20.04

The test presupposes that the data include a deterministic trend. Since the test statistic is larger than the critical value, the series are cointegrated.

b) Engle & Granger's test

Variable	ADF statistic	Critical value 5%	1%
HS	-1.45	-1.94	-2.58
HSINT	-1.72	-1.94	-2.58
HSINV	-1.52	-1.94	-2.58
HSCON	-2.16	-1.94	-2.58
IM	-1.43	-1.94	-2.58
IMINT	-1.42	-1.94	-2.58
IMINV	-1.60	-1.94	-2.58
IMCON	-1.67	-1.94	-2.58
DS	-1.34	-1.94	-2.57
DSINT	-1.50	-1.94	-2.58
DSINV	-1.25	-1.94	-2.58
DSCON	-1.99	-1.94	-2.58

The Dickey Fuller test does not include either a trend or an intercept. Since the ADF statistic is larger, in absolute terms, than the critical value, there are no unit roots. The absence of unit roots in the residuals indicates that the series are cointegrated.

4.3. Granger causality

Null hypothesis: No Granger causality from the producer price (the import price) to the CPI. The table shows the probability values for the null hypothesis not being rejected.

Variable

	1 month	12 months
HS	0.036	0.052
HSINT	0.360	0.019
HSINV	0.000	0.136
HSCON	0.552	0.035
IM	0.030	0.042
IMINT	0.109	0.277
IMINV	0.087	0.078
IMCON	0.046	0.123
DS	0.000	0.014
DSINT	0.136	0.231
DSINV	0.530	0.343
DSCON	0.002	0.026

4.4. Estimations (OLS)

a) Model 2

Diagnostic test:

Variable	BG	ARCH	JB	R^2	S.E
HS	0.554	0.404	0.000	0.394	0.005
HSINT	0.471	0.913	0.000	0.237	0.006
HSINV	0.989	0.597	0.000	0.389	0.005
HSCON	0.908	0.144	0.000	0.292	0.006
IM	0.962	0.550	0.000	0.278	0.006
IMINT	0.831	0.546	0.000	0.292	0.006
IMINV	0.547	0.327	0.000	0.306	0.006
IMCON	0.738	0.200	0.000	0.330	0.006
DS	0.516	0.628	0.000	0.352	0.006
DSINT	0.787	0.546	0.000	0.295	0.006
DSINV	0.666	0.387	0.000	0.289	0.006
DSCON	0.237	0.166	0.000	0.413	0.005

BG denotes the Breusch Godfrey test for autocorrelation, ARCH (Auto-Regressive Conditional Heteroscedasticity) the test for heteroscedasticity, JB the Jarque Bera test of whether or not the residuals show a normal distribution, R^2 the explanatory power and S.E the standard error of the regression. The first three columns show the probability values for, respectively, no autocorrelation, no heteroscedasticity and a non-normal distribution of the residuals.

b) Model 3'

Parameter estimation: Home sales prices
The italicised figures are the *t* statistic for the parameter estimate in the preceding column.

Variable*	(1)	*t*	(2)	*t*	(3)	t
C	0.00	*-2.34*	0.01	*4.75*	0.00	*0.96*
d U					0.09	*2.37*
d U(-1)	0.14	*3.74*	0.12	*3.28*	0.15	*4.08*
d D	0.00	*-2.27*			0.00	*-3.10*
d D(-2)						
d D(-4)	0.00	*4.28*			0.00	*3.15*
d HS	0.69	*8.84*				
d2 HS	-0.20	*-2.40*				
d HSINV			0.48	*5.35*		
d2 HSINV(-2)			-0.26	*-3.15*		
d HSCON					0.67	*7.47*
d2 HSCON					-0.25	*-3.46*
DUM	0.03	*7.52*	0.03	*7.71*	0.03	*8.36*

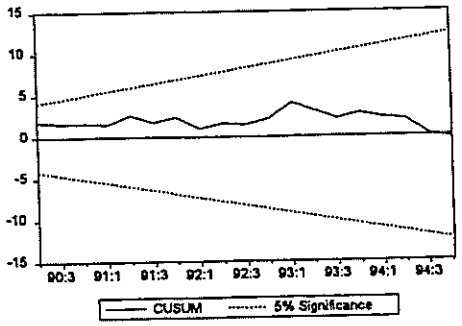
* $d=\Delta$, $d2=\Delta^2$

Diagnostic test:

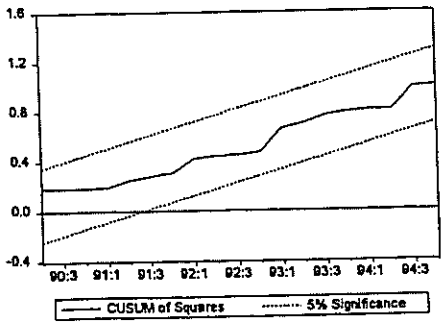
Equation	BG	ARCH	JB	R^2	S.E.
(1)	0.823	0.891	0.829	0.772	0.005
(2)	0.647	0.758	0.036	0.757	0.005
(3)	0.938	0.801	0.516	0.798	0.005

Equation (1): HS

CUSUM:

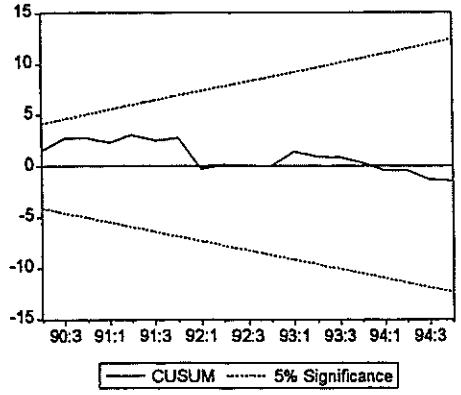


CUSUM square:

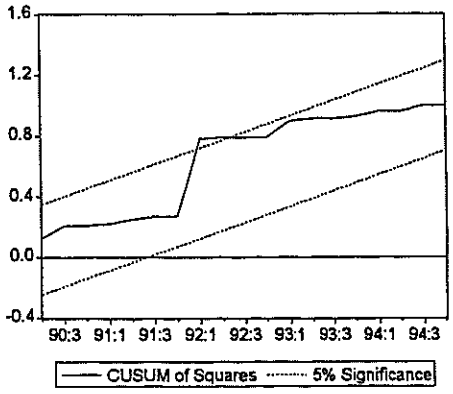


Equation (2): HSINV

CUSUM:

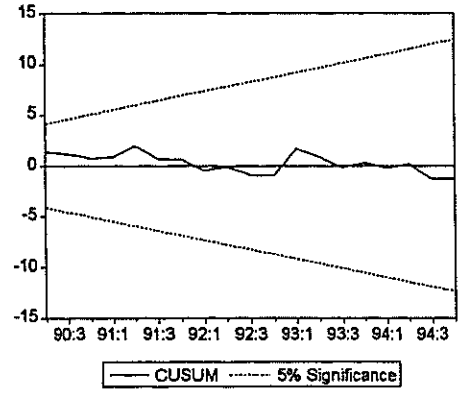


CUSUM square:

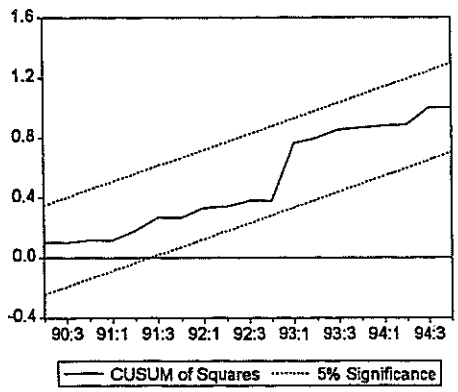


Equation (3): HSCON

CUSUM:



CUSUM square:



The parameters are not stable over time if the cumulative sum of the residuals moves outside the confidence interval (the dotted lines).

Parameter estimation: Import prices
The italicised figures are the *t* statistic for the parameter estimate in the preceding column.

Variable*	(1)	*t*	(2)	*t*	(3)	*t*	(4)	*t*
C	0.01	*5,23*	0,01	*5,79*	0,01	*3,69*	0,01	*4,10*
d U			0,10	*2,34*	0,12	*2,25*	0,17	*3,72*
d U(-1)	0.19	*4,45*	0,15	*3,53*	0,22	*4,37*	0,20	*4,33*
d U(-2)	0.09	*2,19*			0,13	*2,72*		
d U(-4)			0.08	*2.07*				
d D(-1)	0.00	*3.47*			0.00	*2.42*	0.00	*2,03*
d D(-2)	0.00	*-2.74*			0.00	*-3.38*	0.00	*-2,06*
d IM	0.32	*5.18*						
d2 IM	-0.19	*-3.25*						
d2 IM(-1)	-0.12	*-2.42*						
d2 IM(-2)	-0.10	*-2.44*						
d2 IM(-3)	-0.11	*-2.98*						
d IMINT			0.16	*5.15*				
d2 IMINT			-0.08	*-2.89*				
d IMINV					0.16	*3.04*		
d IMCON							0.29	*5,44*
d2 IMCON							-0.09	*-2,21*
DUM	0.03	*5.63*	0.03	*6.63*	0.03	*5.64*	0.03	*5,65*

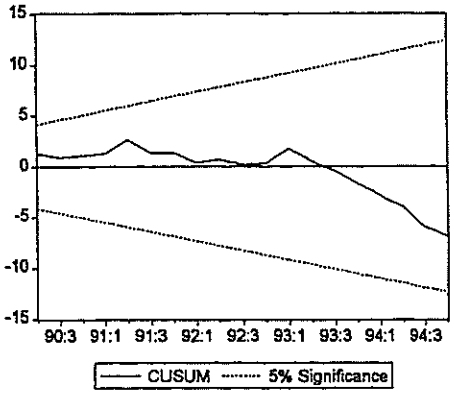
* $d=\Delta$, $d2=\Delta^2$

Diagnostic test:

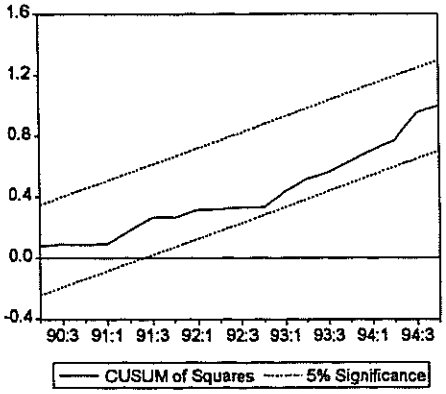
Equation	BG	ARCH	JB	R^2	S.E.
(1)	0.607	0.892	0.398	0.729	0.006
(2)	0.191	0.904	0.306	0.663	0.006
(3)	0.225	0.630	0.463	0.639	0.007
(4)	0.111	0.11	0.284	0.677	0.006

Equation (1): IM

CUSUM:

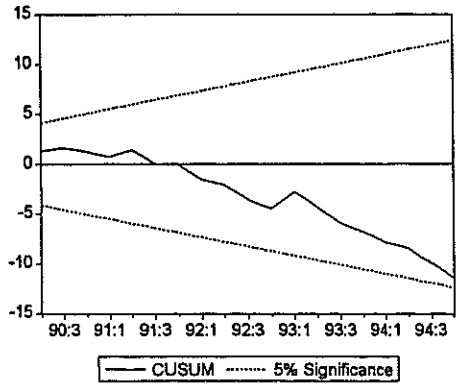


CUSUM square:

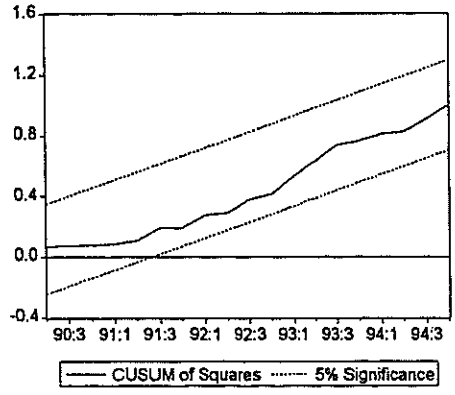


Equation (2): IMINT

CUSUM:

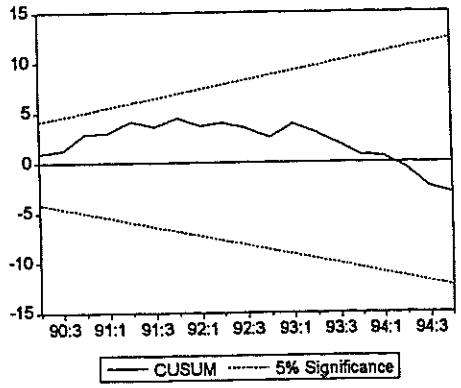


CUSUM square:

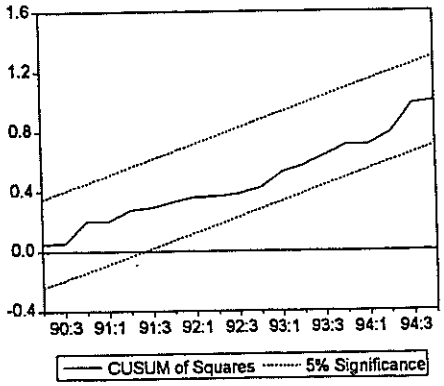


Equation (3): IMINV

CUSUM:

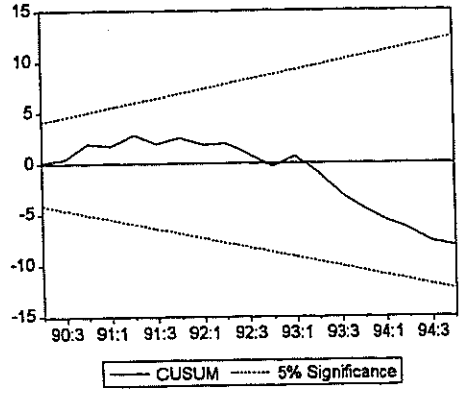


CUSUM square:

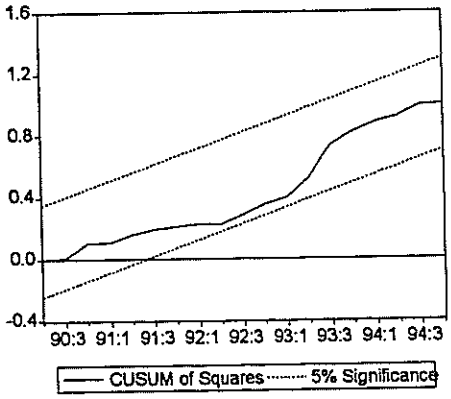


Equation (4): IMCON

CUSUM:



CUSUM square:



The parameters are not stable over time if the cumulative sum of the residuals moves outside the confidence interval (dotted lines).

Parameter estimation: Domestic supply
The italicised figures are the *t*-statistic for the parameter estimate in the preceding column.

Variable*	(1)	*t*	(2)	*t*	(3)	*t*	(4)	*t*
C	0.01	*4.52*	0.01	*5.79*	0.01	*3.80*	0.00	*1.74*
d U							0.14	*4.05*
d U(-1)	0.11	*2.70*	0.13	*3.05*	0.14	*3.29*	0.19	*5.59*
d U(-2)								
d U(-4)			0.09	*2.21*	0.09	*2.30*		
d D(-1)	0.00	*2.84*						
d D(-2)	0.00	*-2.12*					0.00	*-2.06*
d D(-4)	0.00	*2.30*					0.00	*2.77*
d DS	0.58	*7.68*						
d2 DS	-0.29	*-3.52*						
d2 DS(-1)	-0.17	*-2.22*						
d2 DS(-2)	-0.17	*-2.51*						
d2 DS(-3)	-0.17	*-3.10*						
d DSINT			0.29	*5.53*				
d2 DSINT			-0.13	*-2.58*				
d DSINV					0.38	*4.92*		
d2 DSINV					-0.14	*-1.99*		
d2 DSINV(-2)					-0.17	*-2.75*		
d2 DSINV(-3)					-0.13	*-2.03*		
d DSCON							0.54	*8.70*
d2 DSCON							-0.17	*-3.44*
DUM	0.03	*6.48*	0.03	*7.19*	0.03	*6.69*	0.03	*8.41*

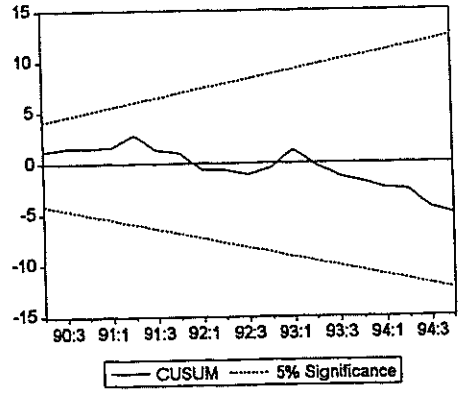
* $d=\Delta$, $d2=\Delta^2$

Diagnostic test:

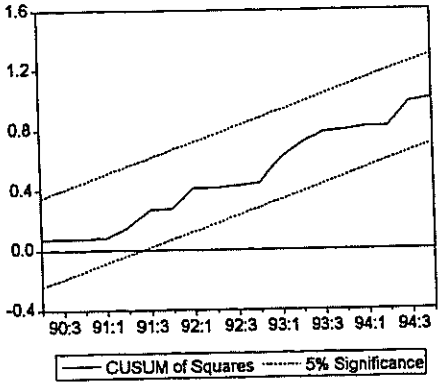
Equation	BG	ARCH	JB	R^2	S.E.
1	0.811	0.233	0.656	0.801	0.005
2	0.453	0.755	0.436	0.665	0.006
3	0.612	0.874	0.69	0.677	0.006
4	0.494	0.203	0.312	0.829	0.005

Equation (1): DS

CUSUM:

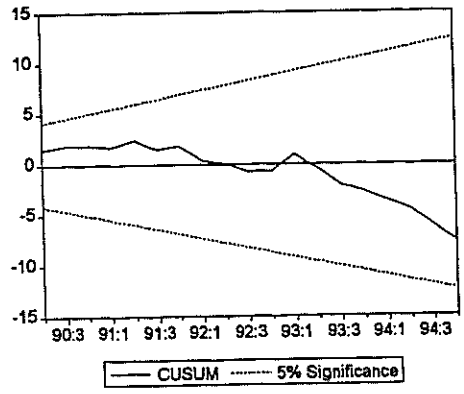


CUSUM square:

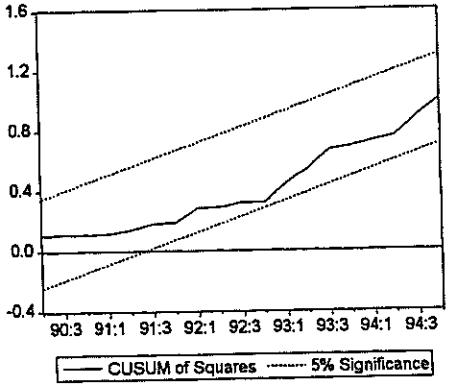


Equation (2): DSINT

CUSUM:

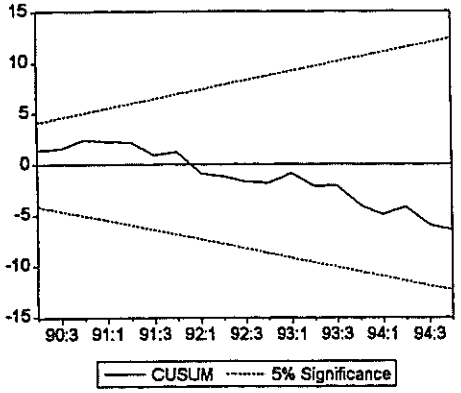


CUSUM square:

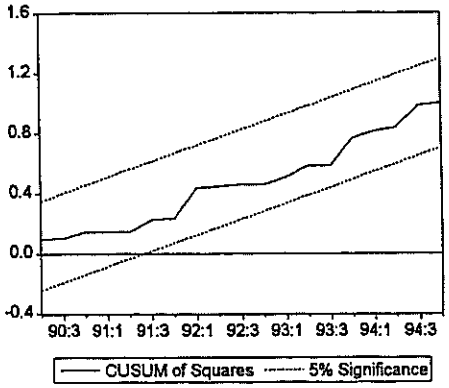


Equation (3): DSINV

CUSUM:

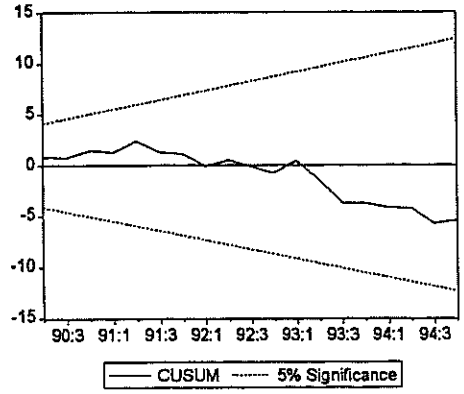


CUSUM square:

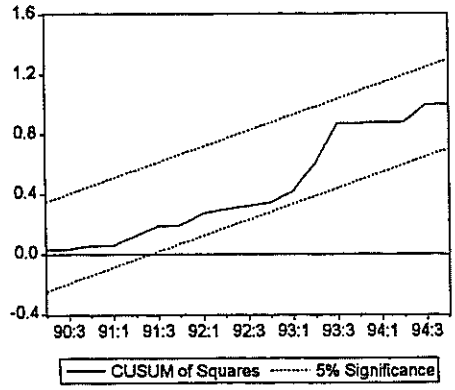


Equation (4): DSCON

CUSUM:



CUSUM square:

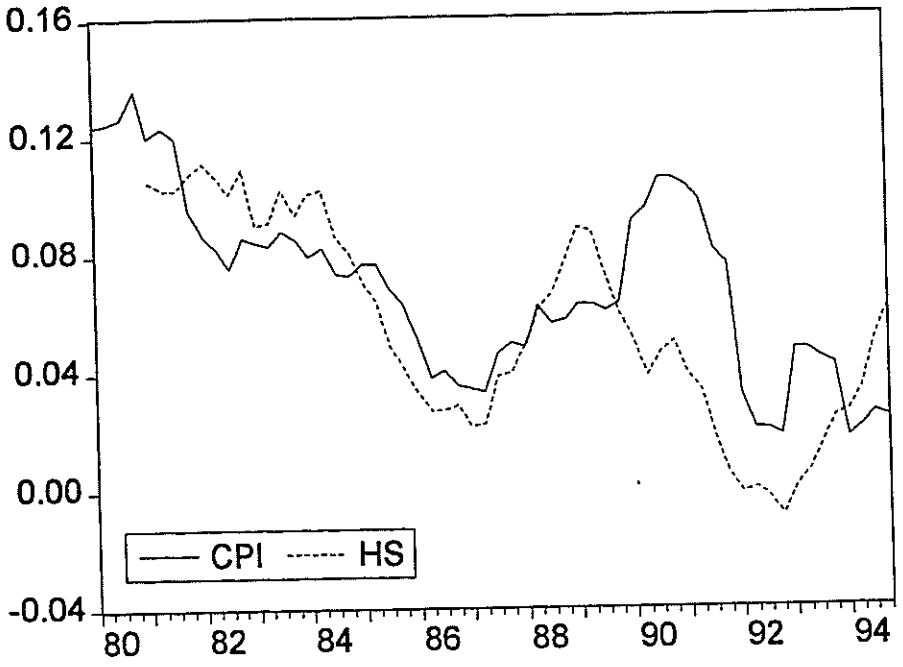


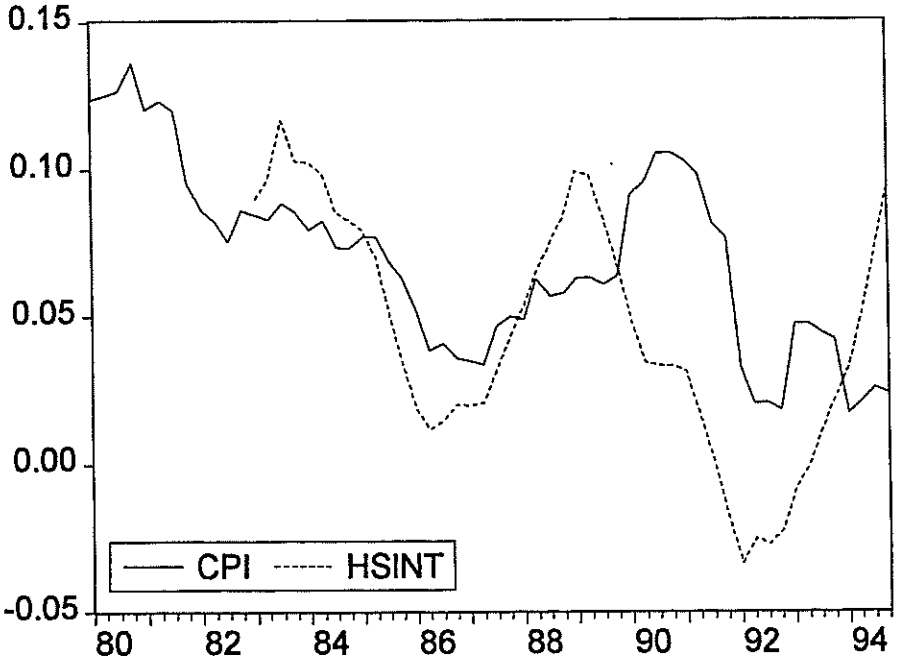
The parameters are not stable over time if the cumulative sum of the residuals moves outside the confidence interval (dotted lines).

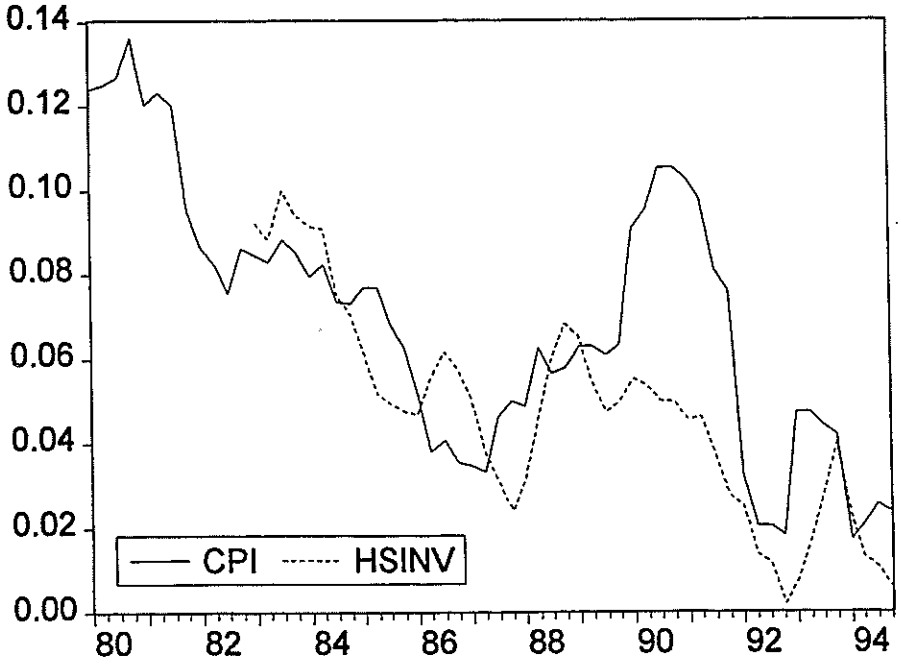
Annex 3. The change in CPI and various producer and import prices

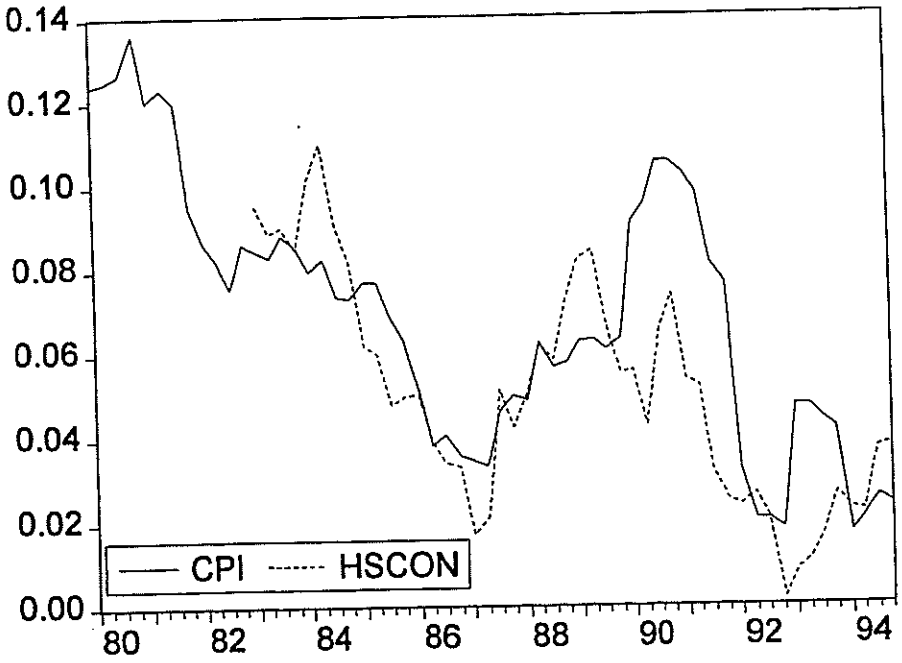
The following charts show the annual percentage changes in the CPI and in the various indices of producer and import prices.

Home sale prices:

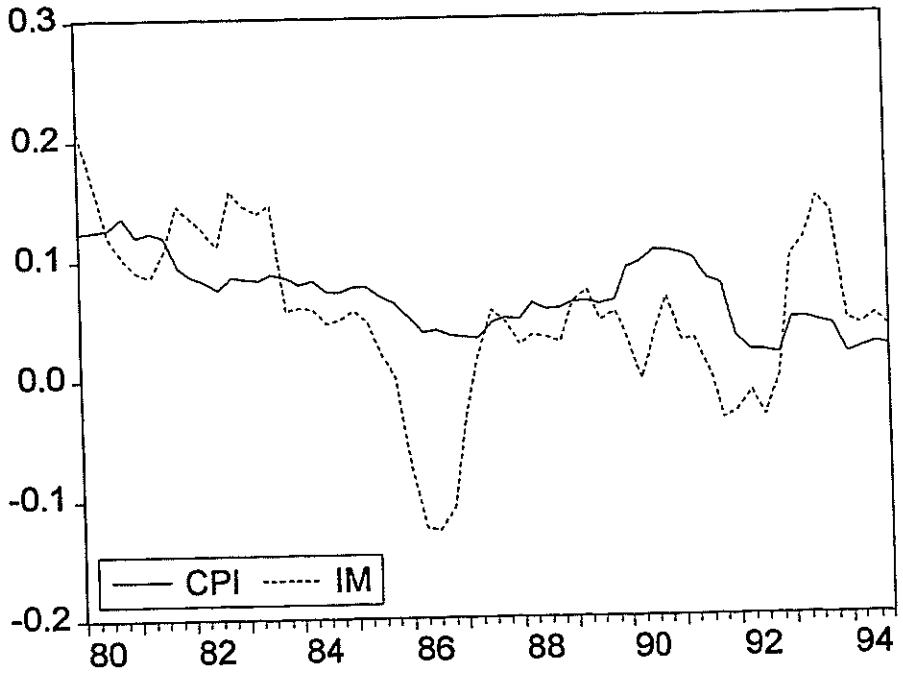


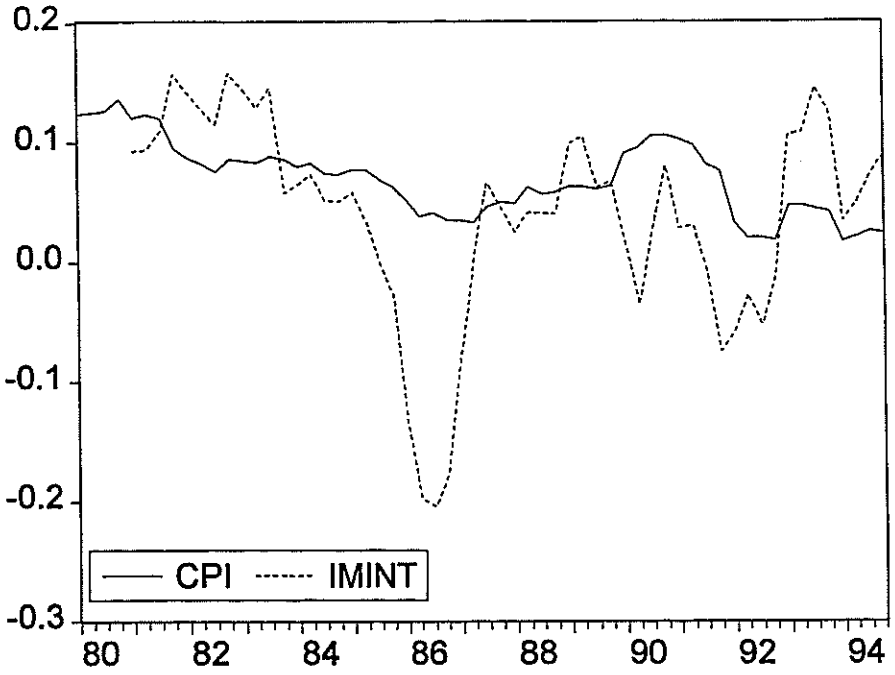

0.15
0.10
0.05
0.00
-0.05
80
82
84
86
88
90
92
94
CPI
HSINT

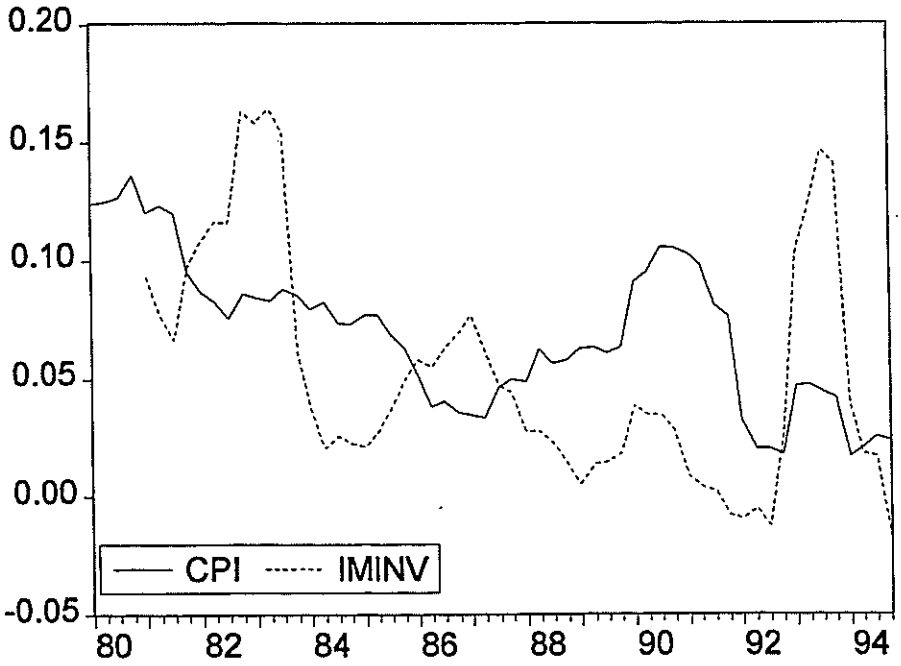

0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
80
82
84
86
88
90
92
94
CPI
HSINV

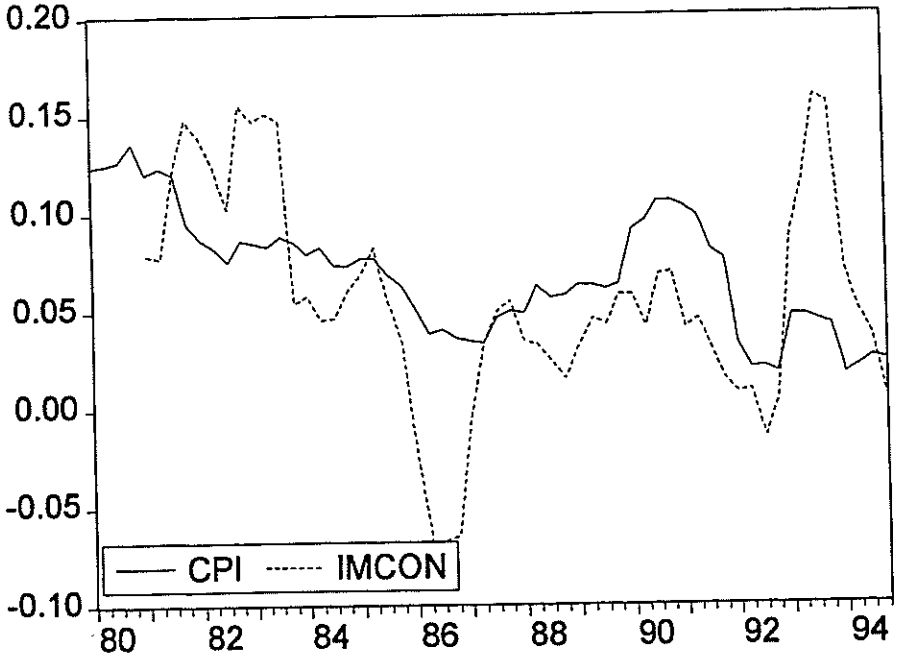


Import prices:

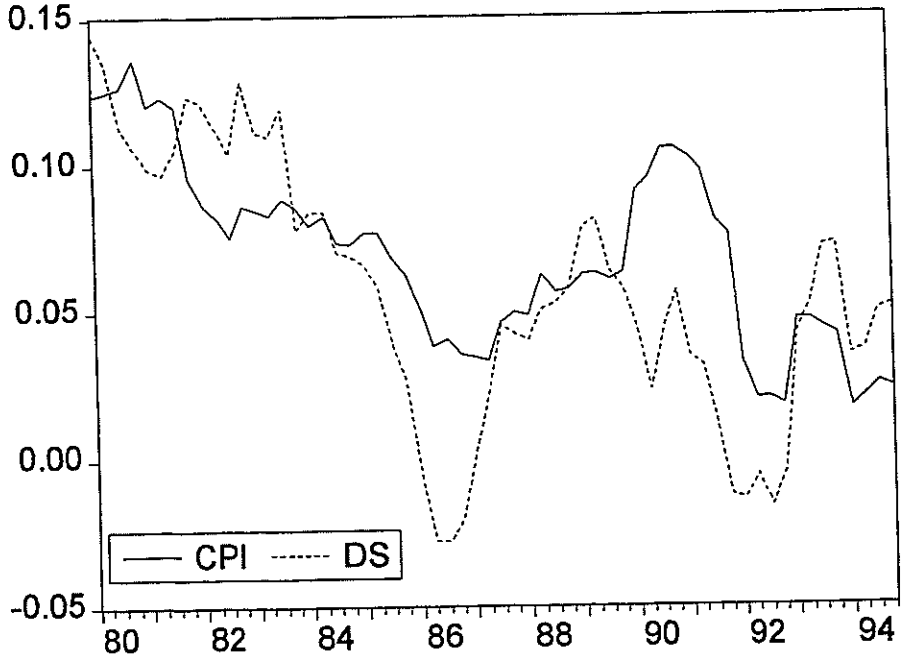


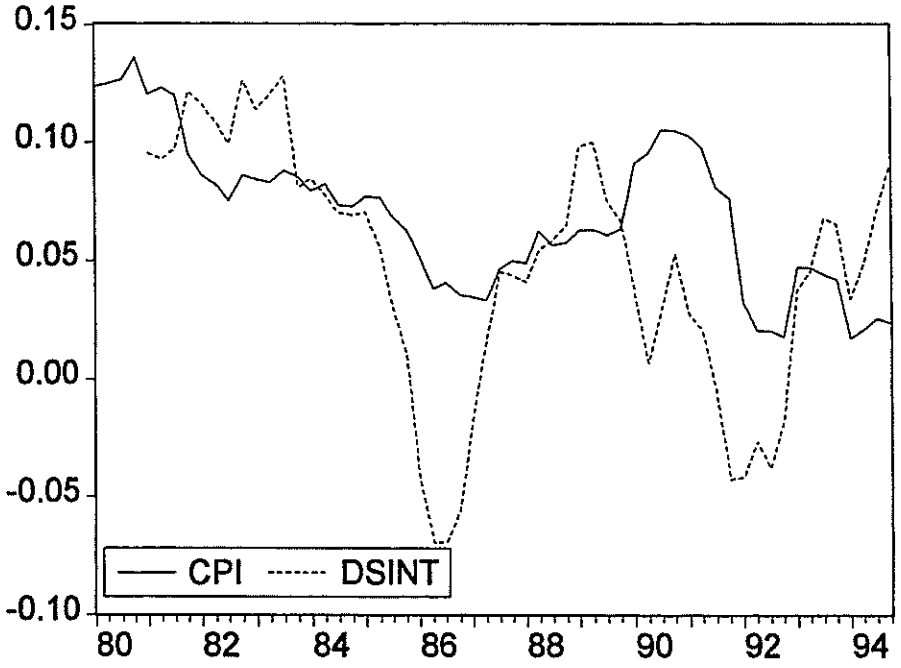

0.2
0.1
0.0
-0.1
-0.2
-0.3
CPI
IMINT
80
82
84
86
88
90
92
94

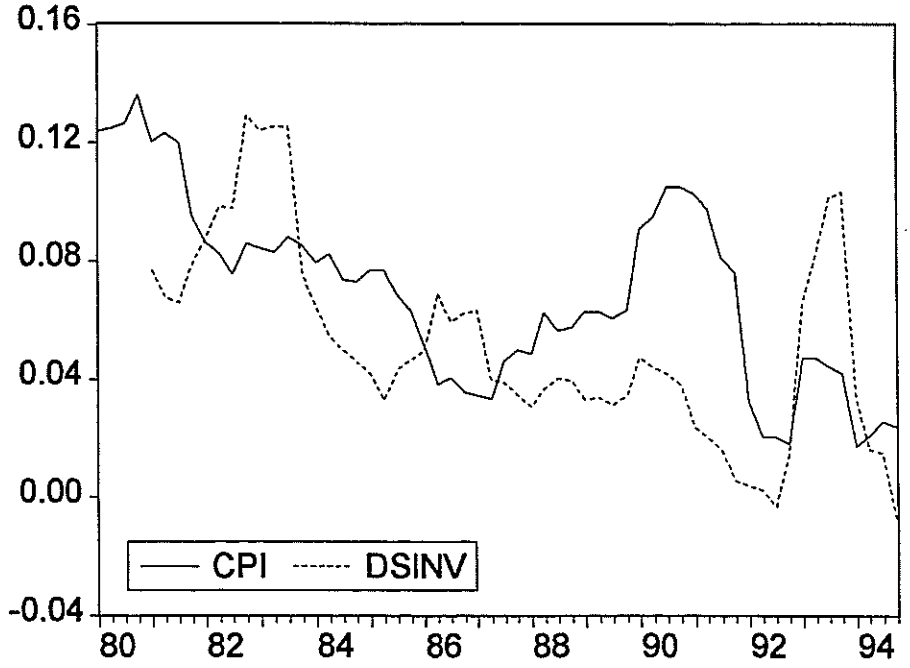

0.20
0.15
0.10
0.05
0.00
-0.05
CPI
IMINV
80
82
84
86
88
90
92
94

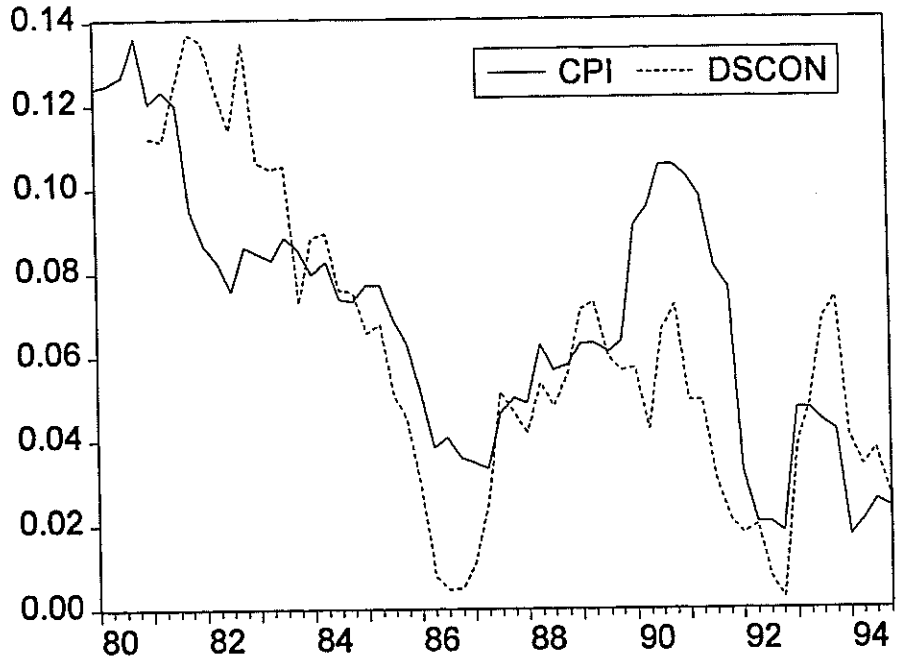


Domestic supply:




0.15
0.10
0.05
0.00
-0.05
-0.10
80
82
84
86
88
90
92
94
CPI
DSINT


0.16
0.12
0.08
0.04
0.00
-0.04
80
82
84
86
88
90
92
94
CPI
DSINV


CPI
DSCON
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
80
82
84
86
88
90
92
94

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