WP/03/250

IMF Working Paper

Determinants of Deflation in Hong Kong SAR

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Asia and Pacific Department

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December 2003

Abstract

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This paper presents a comprehensive econometric analysis of the determinants of deflation in Hong Kong SAR. The analysis helps to determine the relative contributions of factors such as increased productivity, scarce money supply, and excess capacity in determining deflation. The main conclusion is that the effects of permanent shocks, such as productivity shocks and shocks related to changes in the money supply and price convergence with trading partners, have become more important in explaining deflation. In addition, the effects of temporary shifts in aggregate demand have been perpetuated by negative wealth and balance-sheet effects in the corporate and household sectors arising from asset-price declines over the past five years.

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I. OVERVIEW

Hong Kong SAR has experienced continuous deflation since the last quarter of 1998. The composite consumer price index (CPI) fell by almost 14 percent between the third quarter of 1998 and December 2002; about half of this is accounted for by a decline in housing costs, following the bursting of the bubble in property prices in the mid-1990s.[2] Other items that have contributed significantly to the decline in prices include food, clothing and footwear, and durable goods (Table 1). Falling prices have contributed to increased real debt burdens, depressed consumer confidence, tightened monetary conditions, and could have helped feed the contraction in aggregate demand (Table 2).

Table 1: Contributors to Deflation

	Weight	Cumulative Change Sep 1998-Dec 2002 (percent) 1/	Contribution to overall deflation (percentage points)	Contribution to overall deflation (share)
Composite CPI 2/	100.0	-13.7	-13.7	100.0
of which:				
Food	26.7	-7.7	-2.1	15.0
Housing	29.9	-26.2	-7.8	57.3
Electricity, Gas and Water	3.0	-5.0	-0.2	1.1
Alcoholic Drinks and Tobacco	0.9	5.1	0.0	-0.4
Clothing and Footwear	4.1	-35.5	-1.5	10.7
Durable Goods	6.2	-27.2	-1.7	12.4
Miscellaneous Goods	5.7	3.7	0.2	-1.6
Transport	9.0	-0.2	0.0	0.1
Miscellaneous Services	14.4	-4.9	-0.7	5.2

Sources: CEIC database; and IMF staff calculations.
1/ Based on log-difference approximation.
2/ Sum of the components using fix weights over the period September 1998 to December 2002.

Table 2. Economic Indicators

	Period Average 1993Q3-1997Q3	Period Average 1998Q3-2002Q4
Real GDP (year on year percent change)	5.03	3.00
Real Domestic Demand (year on year percent change)	6.67	-0.21
Consumption, real (year on year percent change)	4.96	0.49
Gross Fixed Capital Formation, real (year on year percent change)	11.17	-3.08
Real Interest Rates 1/	0.38	10.60
Real Interest Rates 2/	-2.71	6.95
Unemployment Rate 3/	2.20	7.20

Sources: CEIC Database; and IMF staff calculations.
1/ Best lending rate minus actual yoy CPI inflation.
2/ Interbank offered rate minus actual yoy CPI inflation.
3/ level of unemployment rate prevailing in 1997Q3 and 2002Q4.

This paper presents a comprehensive analysis that provides a decomposition of the aggregate price level into transitory and permanent components, and identifies the nature and origin of the shocks that drive these two components. The analysis is based on a methodology with

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[2] July 2003 figures indicate that deflation is continuing: prices fell by 4.0 percent, year-on-year, although this sharp decline is partly attributable to temporary utility rate concessions granted by the government.

several features that are useful for analyzing deflation and its persistence. First, it provides a clear distinction between those driving forces behind deflation that create trend movements in the variables (summarized in the permanent component) and those that generate temporary deviations from long-run equilibrium conditions (summarized in the transitory component). Second, it provides means for identifying the nature of those forces. The approach undertaken here is a "structural" one, as opposed to the commonly used "reduced-form" approach. It helps, for example, to determine whether falling prices result from one or more of the following: increased productivity, scarce money supply, and temporary excess capacity. This is particularly relevant, because the likely duration of deflation, its costs, and the policy actions that may need to be taken to combat it all depend upon the nature of the deflation's underlying causes.

Empirical evidence suggests that the contribution of the permanent component has become relatively more important over time in explaining deflation. The sustained fall in the aggregate price level is mostly accounted for by continuous declines in its permanent component, which summarizes the cumulative effects of productivity shocks, scarce money supply, and price convergence with trading partners. In addition, the findings indicate that although the transitory component did contribute significantly to the initial phase of deflation, its effects are becoming progressively weaker.

The remainder of the paper is organized as follows. Section II presents the model that has been used for analyzing deflation. It explains how the price level is decomposed into transitory and permanent components that reflect the effects of shocks that have an economic interpretation. These shocks are identified by imposing restrictions that are derived from economic theory. Section III presents the results. Section IV provides an interpretation of the results. Section V concludes the paper.

II. THE FRAMEWORK

A structural vector error correction modeling approach à la King and others, (1991) is used to assess the nature and impact of shocks on prices to shed light on the main factors that are behind their sustained decline. The structural vector error correction model, also known as the common trends model (CTM), is well suited for analyzing the interaction between variables that display trends and are determined simultaneously, uses general restrictions derived from economic theory to identify the main driving forces behind the trends observed in aggregate macroeconomic variables, and ensures consistency between the short run and long-run dynamics of those variables.[3]

The CTM includes the following variables: real output, measured as nominal GDP deflated by the (composite) CPI; broad money; the CPI; real asset prices, measured by the Hang Seng

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[3] Technical details are presented in Appendix I.

stock index deflated by the consumer price index; foreign prices in Hong Kong Dollars (HK$), measured as the trading partners CPI expressed in HK$.[4]

Figure 1 provides a diagrammatic representation of this framework. It shows how the outturn the price level can be decomposed into two components that reflect its short run and trend movements, and what are their main driving forces.

> Panel I displays several possible factors that could, at each point in time, influence different sides of the economy (for example, supply versus demand, nominal versus real).

> The occurrence of an event related to these factors constitutes a "shock." The nature of the shocks is determined according to which side of the economy they first have an impact on, as well as the temporal nature of the shock (Panel II). There are two types of shocks: transitory shocks, which generate only short-run movements in the variables; and permanent shocks, which generate both short run and trend movements in the variables.[5] The transitory shocks are: cost-push shocks (for example, changes in mark-up margins), aggregate demand shocks (for example, temporary shift in consumers' preferences), and liquidity preference shocks. The permanent shocks are: real (for example, productivity) shocks, and changes in the money supply.[6]

> Each of these shocks generates particular movements in the variables of the system that distinguish it from the others, (Panel III). For example, the so-called "real" shock, which is related to factors such as productivity changes or labor market reforms, generates short-run movements (for example, deviation from long-run equilibrium conditions) and trend movements in all variables, whether the latter are

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[4] There are three main reasons why stock prices have been used in lieu of property prices. First, the former ensures consistency with the predictions of economic theories that suggest the existence of a stable long-run arbitrage relationship between output and real stock prices (see, for example, Blanchard, 1981). Second, it provides a means for capturing, in a broad sense, the effects of changes in asset prices on both the corporate sector's balance sheets and households' wealth. Third, stock prices are highly correlated with property prices—the correlation between stock prices and property prices over 1980: Q4-2002: Q3 is 0.85, suggesting that this approach might not be too restrictive in any case.

[5] Note that, even the transitory shocks could, through their effects on private sector balance sheets, have persistent effects on prices that last beyond the duration of the shocks themselves.

[6] The term "changes in the money supply" refers to increases (decreases) in the money supply beyond (below) what is required to finance long-run real GDP. It is also worth noting that real shocks could also include those changes in the supply of goods and services that are due to wealth/balance-sheets effects resulting from, for example, shifts in investors' sentiment.

real or nominal. The "nominal" shock generates short-run movements in all the variables and trends in only those variables that are nominal. The cost-push shock generate short-run movements in all variables, but does not affect their trends.

➢ The distinction between these two types of shocks constitutes the pillar of the decomposition of each variable into a transitory component and a permanent component (Panel IV). For each variable, the combination of the short-run movements generated by both types of shocks constitutes its transitory component; while that of the effects of the permanent shocks on its trend or long-run dynamics constitute its permanent component.

The identification of the shocks that drive these two components is based on restrictions that are derived from economic theory. They include restrictions that stem from the long-run equilibrium relationships of a stable money demand, purchasing power parity, and arbitrage between output and real stock prices.[7] The money demand equation embeds the monetarist view that, in the long run, inflation/deflation is a monetary phenomenon. Purchasing power parity captures the effects of price convergence with trading partners. The arbitrage relationship between output and real stock prices captures the idea that certain developments in the real (supply) side of the economy, such as improved productivity or labor market reforms, can engender trends in asset prices because of their impact on current and prospective levels of corporate profitability. Additional restrictions that include the concept of long-run neutrality of money (vertical Phillips Curve) and assumptions on stickiness in the adjustment process of certain variables to shocks are also used to obtain an exact identification of all shocks in the system.

The interpretation of the permanent and transitory components of each variable depends upon the effects of which shocks they include. For example, because the transitory component of output includes the short-run effects of productivity shocks, it can not be literally considered as a standard measure of output gap that would convey the notion of pressures arising only from the demand side of the economy.

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[7] These restrictions were tested jointly since the Johansen maximum likelihood estimation procedure indicated the existence of three cointegrating relationships. The purchasing power parity restriction, when tested separately, was not rejected at the 5 percent significance level. See Becker (1999), Cassola and Morana (2002) for examples of studies using similar restrictions.

Figure 1. Effects of Shocks on Prices
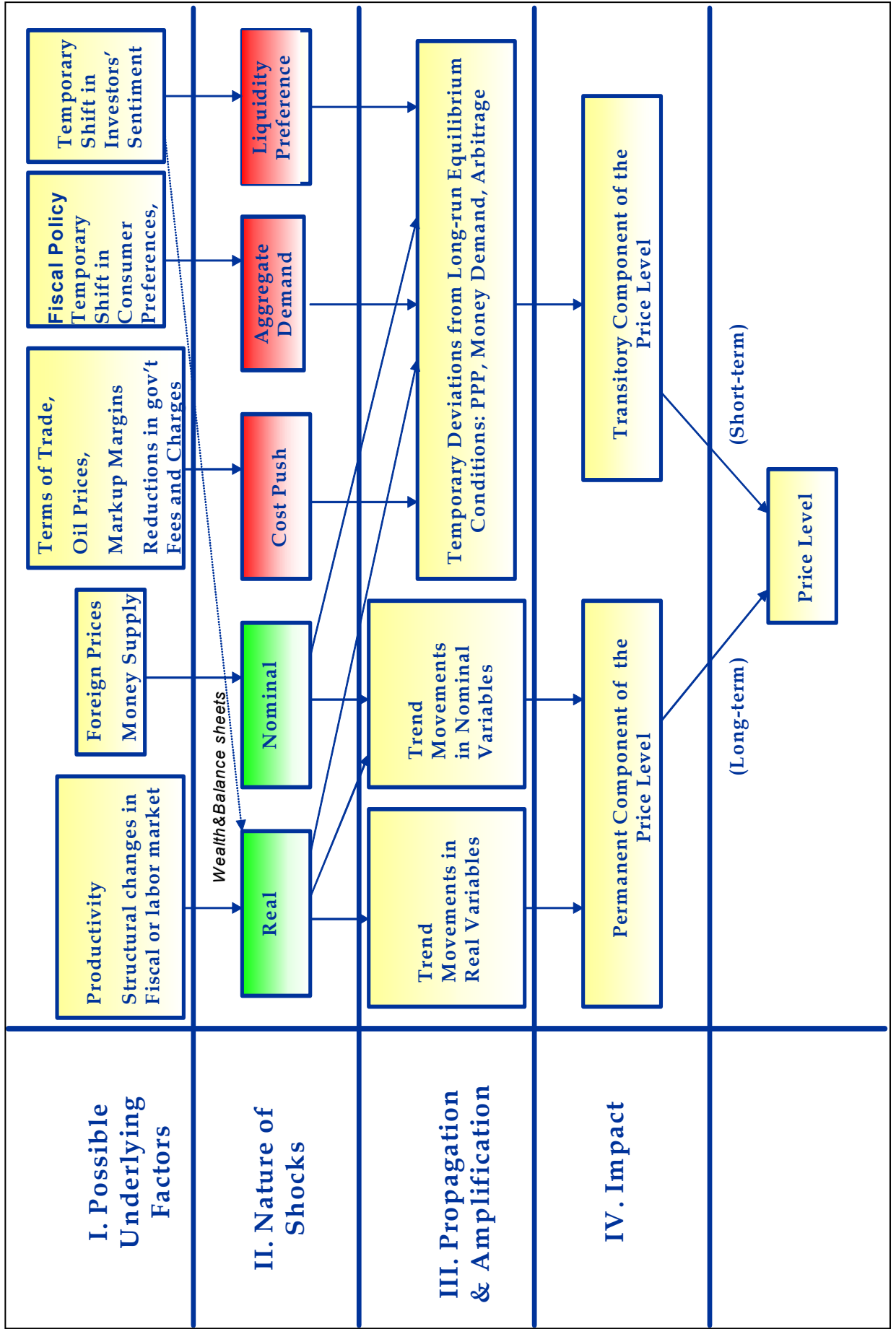
III. RESULTS

Over the 1998: Q4-2002: Q3 period, the decline in the price level has been associated with a decline in both its transitory and permanent components. Although downward pressures on the price level resulting from the decline in the transitory component have been very pronounced during the initial phase of deflation, these have become progressively weaker. Consequently, most of the fall in the price level between 2001: Q3 and 2002: Q3 is accounted for by the decline in its permanent component (Figure 2).

Figure 2. Prices: Actual and Permament and Transitory Components

Sources: CEIC Database and IMF staff estimates.
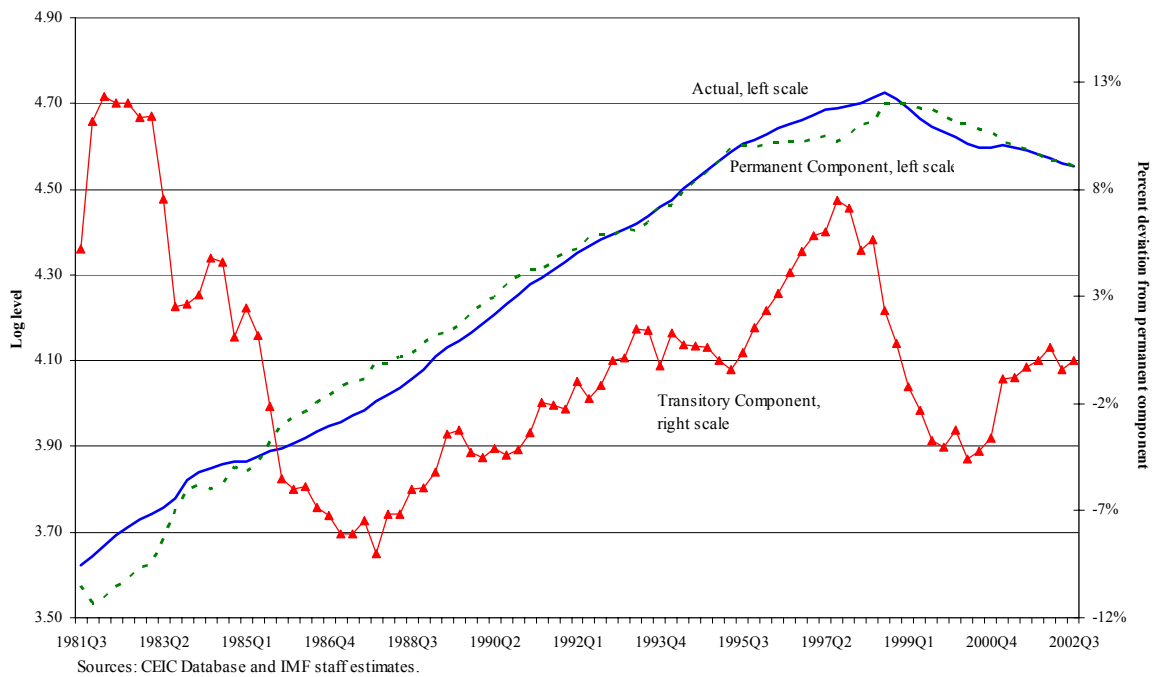
The sustained fall in prices results mostly from the effects of permanent shocks that determine entirely the path of the permanent component of prices, and have a substantial impact on the transitory component. Over the deflation period, the effects of transitory shocks on the transitory component of prices have been outweighed by those of permanent shocks (Figure 3). Shocks such as productivity shocks, changes in the money supply, and price equalization with trading partners have had a significant negative impact on the transitory component of prices over the 1998: Q4-2002: Q3 period.

Figure 3. Transitory Component of Prices: Contributions of Transitory Shocks
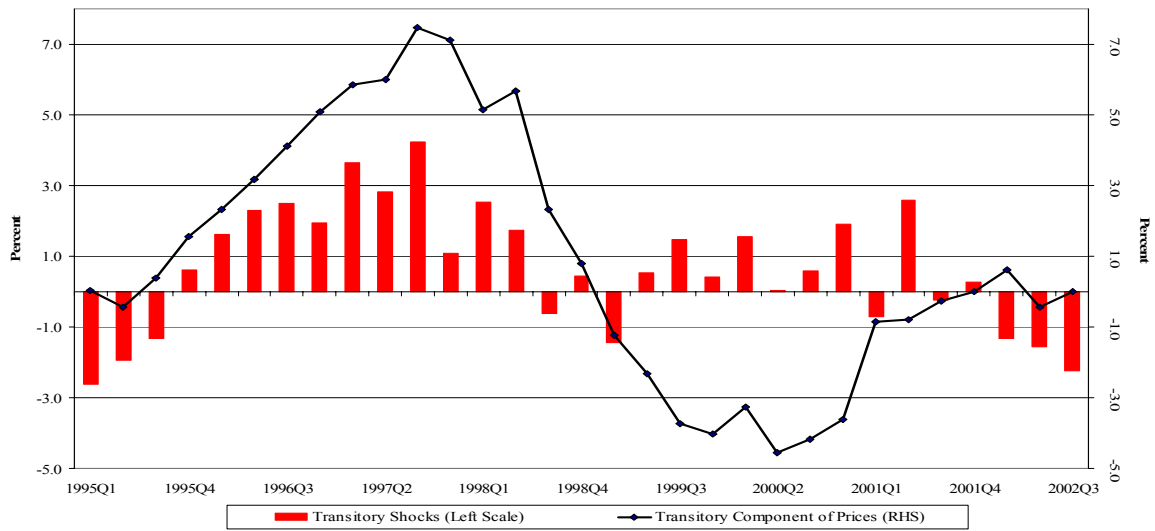
Sources: IMF staff estimates.

In terms of the *rate of change* in prices (that is, inflation or deflation), the estimates of the permanent component of prices show continued deflation owing to permanent shocks, such as productivity shocks, changes in money supply, and price equalization with trading partners over the last two years (see, the graph of the permanent component in Figure 4).[8]

Figure 4. Year-on-Year Inflation Rate: Actual and Permanent and Transitory.
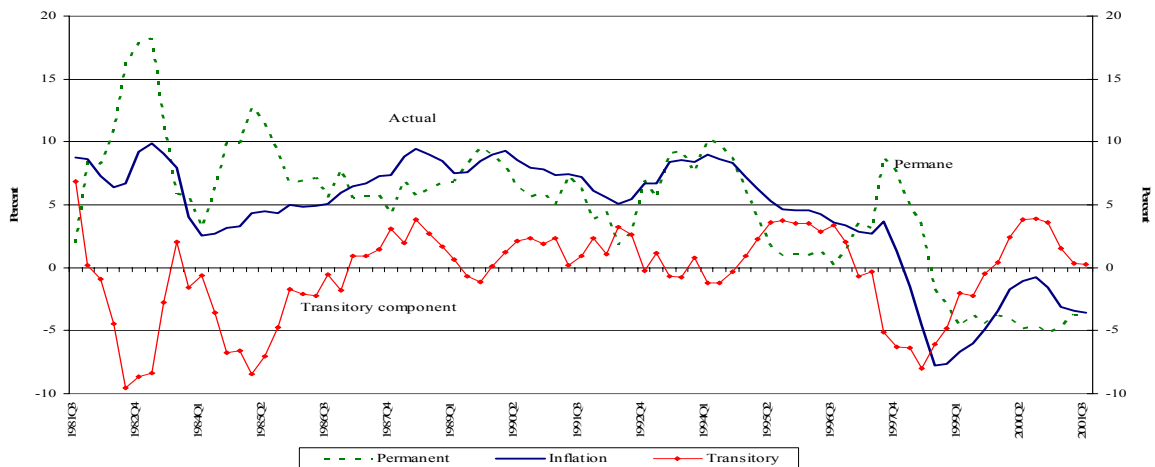
Sources: CEIC Database and IMF staff estimates.

One approach to understanding the relative importance of different shocks is to examine their relative contributions to the variability of prices and output (Table 3).

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[8] The permanent component of the *rate of change* in prices has been obtained from the estimates of the permanent component of the *price level* displayed in Figure 2.

A. Prices

Permanent shocks contribute 44 percent of the fluctuations in prices over the short term (one quarter) and 94 percent over the long term (forty quarters). The relative contributions of each of these shocks are as follows:

- Productivity shocks and shocks related to changes in the aggregate money supply and price equalization with trading partners account for 34 percent and 60 percent of the long-term fluctuations in prices, respectively.

- In the short (one quarter) and medium term (12 quarters), however, productivity shocks are the main sources of variability in prices, accounting for 39 percent and 44 percent of fluctuations in prices, respectively.

The contributions of transitory shocks represent about 56 percent of fluctuations in prices in the short term, which declines to about 35 percent in the medium term. They can be decomposed as follows:

- Cost-push shocks, which could reflect temporary changes in firms' mark-up margins or rates concessions and waivers of water and sewage charges granted by the government, contribute the most to the variability of prices. They explain about 55 percent of fluctuations in prices in the short term, and about 13 percent in the medium term.

- Aggregate demand shocks, such as discretionary fiscal policies or temporary changes in consumers' confidence, do not have an immediate effect on prices, but explain about 16 percent of their fluctuations in the medium term.

- The effects of liquidity-preference shocks on the aggregate level of prices are limited. Liquidity preference shocks explain only about 6 percent of the fluctuations in prices in the medium term.[9]

Results (not reported here) of the historical decomposition of the price level into the components attributable to different shocks tell a similar story. Movements in the price level are largely determined by productivity shocks and shocks to the money supply and price equalization with trading partners.

B. Output

Permanent shocks contribute to 55 percent of output fluctuations in the short term and about 93 percent in the long term, the details of which are as follows:

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[9] Because these transitory real-asset price shocks do not create changes in households' wealth and/or corporate balance sheets that lead to permanent changes in output, they could reflect swings in investors' sentiment that affect the stock market without affecting the bond market significantly. Such shocks would leave market interest rates unchanged.

- Real shocks (productivity shocks) and nominal shocks (changes in the aggregate money supply and price equalization with trading partners) explain 88 percent and 5 percent of output fluctuations in the long term, respectively. These shocks also account for an important part of its fluctuations in the short term: 44 percent and 9 percent, respectively.

The contributions of the transitory shocks represent 48 percent of output fluctuations in the short term, and decline to about 22 percent over the medium term. The respective contributions of each transitory shock is as follows:

- Cost-push shocks account for 8 percent of the variability of output over the medium term.

- Aggregate demand shocks explain about 48 percent of the short-term variability of output. Their relative contribution declines, however, to about 11 percent over the medium term.

- Liquidity-preference shocks explain about 3 percent of the variability of output over the medium term.

Table 3. Forecast Error Variance Decomposition

| | Permanent Shocks | | | | | | | Transitory Shocks | | | | | | | | | |
| | Real | | | | Nominal | | | | Liquidity Preference | | | | Cost Push | | | | Aggregate Demand | | |
	S	M	L		S	M	L		S	M	L		S	M	L		S	M	L
Price Level	0.39	0.44	0.34		0.05	0.21	0.60		0.00	0.06	0.01		0.55	0.13	0.03		0.01	0.16	0.03
Output	0.44	0.66	0.88		0.09	0.12	0.05		0.00	0.03	0.01		0.00	0.08	0.02		0.48	0.11	0.04
Money	0.13	0.27	0.52		0.63	0.58	0.41		0.23	0.12	0.05		0.00	0.01	0.01		0.01	0.02	0.01
Foreign Price Level	0.43	0.19	0.20		0.13	0.63	0.68		0.11	0.06	0.04		0.17	0.08	0.05		0.17	0.04	0.04
Real Stock Prices	0.49	0.57	0.67		0.09	0.06	0.08		0.42	0.27	0.17		0.00	0.07	0.05		0.00	0.03	0.03

Source: IMF staff estimates.
Notes:
S=short-term (1 quarter)
M=medium-term (12 quarters)
L=long-term (40 quarters)

Another approach to understanding the relative importance of shocks is to analyze their dynamic effects on prices. Such an analysis has several uses. First, it provides a means to verify the consistency of the effects of shocks with standard predictions of economic theory, and therefore make an assessment of the validity of the identification restrictions used. Second, it provides information about how shocks are propagated and amplified throughout the economy. The dynamic effects on prices of one-time shocks of different types (Figure 5, suggest the following:

- The responses of prices to shocks are consistent with the predictions of standard economic theory. From an aggregate-supply/aggregate-demand perspective, a temporary real shock (e.g. one-time increase due to higher productivity) that, say, corresponds to an outward shift of the long-run aggregate supply curve, leads to a permanent decrease in prices (and increase in output). A temporary negative aggregate demand shock (of a Keynesian style), leads to an inward shift of the

aggregate demand curve that induces a fall in prices in the short run. With downward stickiness in wages, real wages increase leading to a decline in output and higher unemployment. In the long run, as the aggregate supply curve flattens, prices go back to their initial levels.[10]

The adjustment of prices to transitory shocks is gradual, which suggests some degree of stickiness. The maximum effect is reached after seven quarters in response to an aggregate demand shock, four quarters in response to a cost-push shock, and eight quarters after a liquidity-preference shock.[11]

IV. INTERPRETING THE RESULTS

The large relative contribution of permanent shocks (productivity, money supply/price convergence shocks) to fluctuations in prices, compared to temporary shocks such as aggregate demand and cost push shocks, probably reflects the increased degree of integration between Hong Kong SAR and the mainland and scarce money supply.[12] This implies that downward pressures could continue in the foreseeable future since: (i) price differentials between Hong Kong SAR and the mainland cities such as Shenzhen and Guangdong remain substantial; and (ii) the stance of monetary policy in the United States could tighten when the economy recovers. Moreover, given that wage differentials between Hong Kong SAR and mainland cities have not narrowed substantially, the convergence process is very likely to continue in the near future.
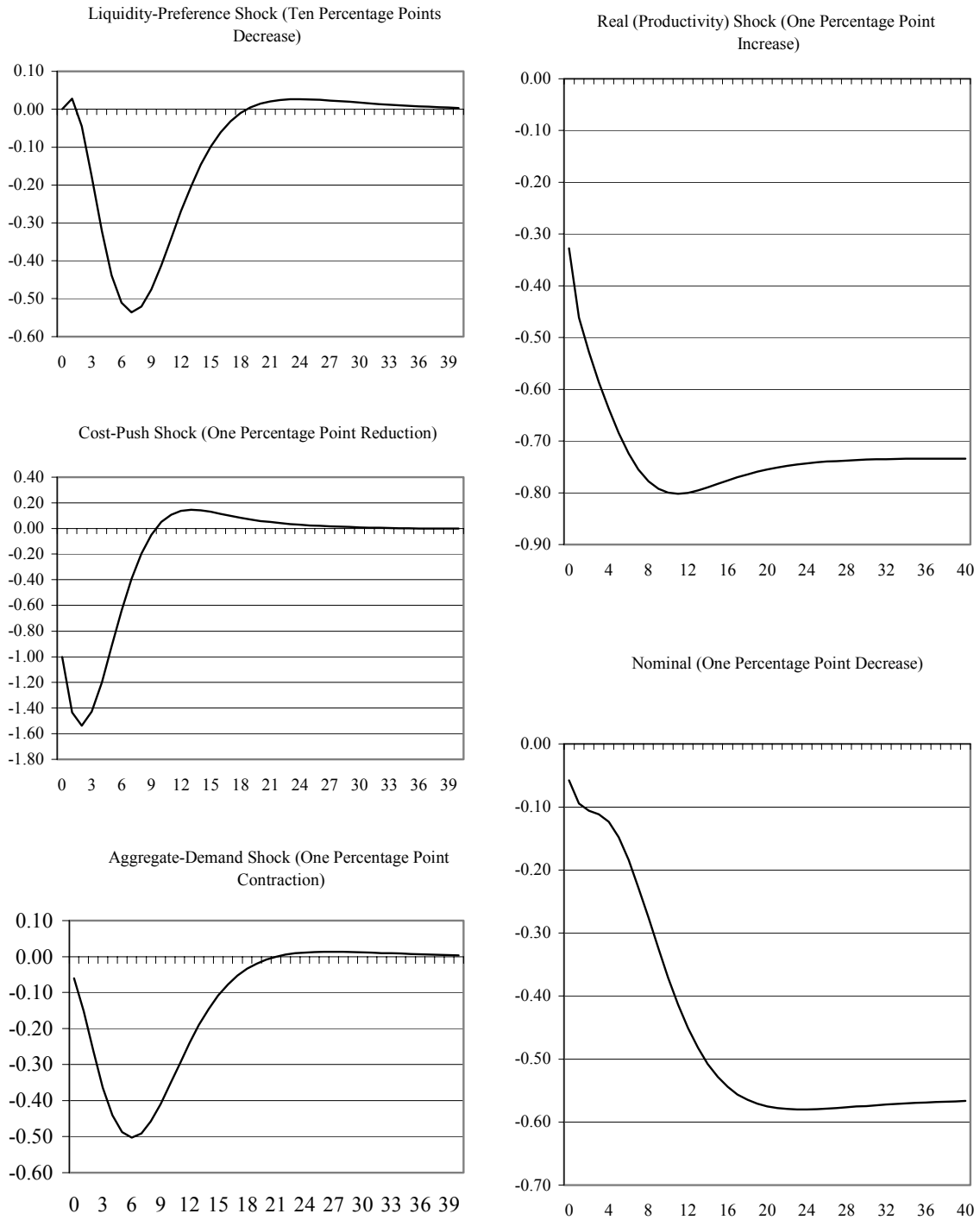
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[10] Although the magnitudes and duration of the transitory effects of these shocks are determined empirically, their zero long-run impact on the price level are imposed by the identification scheme.

[11] Although the half-life of deviations from purchasing power parity appears not to be independent of the nature of the shocks that created it, estimates suggest a relatively fast speed of adjustment of the real exchange rate. It takes about eight quarters for half the effects of a cost-push shock to disappear, while half the effects of an aggregate-demand shock disappear only after 12 quarters.

[12] Under the linked exchange rate regime, changes in the U.S. federal funds rate lead to comparable changes in Hong Kong SAR's interest rate (Hong Kong interbank offered rate, or HIBOR). These changes imply adjustments in the monetary base to avoid capital flows that could put pressures on the exchange rate. The relative tightness of the monetary stance in the U.S. for Hong Kong SAR's economy can be inferred from the fact that the stock of broad money stood at or below its permanent level—that is, the level of broad money that is required to finance long-run real output—over the 1996: Q1–2002: Q3 (Figure 12 third panel).

Figure 5. Movements in the Price Level in Response to
Different One-Time Shocks

Liquidity-Preference Shock (Ten Percentage Points
Decrease)

Cost-Push Shock (One Percentage Point Reduction)

Aggregate-Demand Shock (One Percentage Point
Contraction)

Real (Productivity) Shock (One Percentage Point
Increase)

Nominal (One Percentage Point Decrease)

Source: IMF staff estimates.

The limited contribution and duration of the impact of aggregate demand shocks on prices, such as temporary fiscal measures, is consistent with evidence on the narrow tax structure and limited size of the fiscal multiplier in Hong Kong SAR. This result implies, however, that macroeconomic policy actions aimed at managing the demand side of the economy—in this case, expansionary fiscal policies—may be unlikely to have a significant direct effect on price developments.

V. CONCLUSION

The analysis in this paper has shown that the effects of permanent shocks, such as productivity shocks and shocks related to changes in the money supply and price convergence with trading partners, have become more important in explaining deflation. These shocks originate partly on the real side of the economy (for example, changes in productivity) and partly on the monetary side—as a result of scarce money supply and the dynamic adjustment of prices for purchasing-power-parity purposes. In addition, the effects of temporary shifts in aggregate demand have been perpetuated by negative wealth and balance-sheet effects in the corporate and household sectors arising from asset-price declines over the past five years. The analysis has also shown that there is a prevalence of productivity and nominal shocks, such as changes in the money supply and price convergence with trading partners, in explaining price and output fluctuations.

I. Technical Details

This appendix provides technical details about the methodology that has been used for analyzing deflation. The first section provides a brief overview of the structural vector error correction model (common trends model). The second section presents the results of the estimation of the model.

A. Methodology

The common trends model aims at analyzing the interaction between the following five variables: output, noted y_t, broad money,[13] noted m_t; the CPI, noted p_t; trading partners' CPI in Hong Kong dollar (nominal effective exchange rate times foreign prices), noted ep_t^*; and a measure of real stock prices (stock price deflated by CPI), noted f_t. All variables are expressed in natural logarithm. These five variables are grouped into a vector x_t and decomposed into two components: a transitory component and a permanent component.

Representation

Formally, for this analysis, the common trends model (including exogenous variables) admits, after transformation, the following structural vector moving average representation.

$$x_t = x_0 + A\tau_t + \Phi(L)\psi_t + B\sum_{i=1}^{t} z_i + \Gamma(L)z_t \qquad (1)$$

$$\text{where } x_t = \begin{bmatrix} y_t \\ f_t \\ m_t \\ p_t \\ ep_t^* \end{bmatrix},$$

$$\tau_t = \begin{bmatrix} \theta_t \\ \beta_t \end{bmatrix}, \quad \begin{bmatrix} \theta_t \\ \beta_t \end{bmatrix} = \begin{bmatrix} \theta_0 \\ \beta_0 \end{bmatrix} + \begin{bmatrix} \theta_{t-1} \\ \beta_{t-1} \end{bmatrix} + \begin{bmatrix} \vartheta_t \\ \varsigma_t \end{bmatrix}, \qquad (2)$$

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[13] We used HK$ broad money as a measure of the stock of money in the economy. The use of broad money in the system is to account for the existence of a long-run stable money demand relationship and provide a monetarist explanation to deflation—that is, deflation, like inflation, is in the long run a monetary phenomenon. The stock of money supply is determined by the flows of funds in the different sectors of the economy and the stance of monetary policy in the U.S.

$$\omega_t = F\psi_t = F\left[\psi_t^{perm} \quad \psi_t^{trans}\right]',$$

$$\psi_t^{perm} = \left[\vartheta_t \quad \varsigma_t\right]', \; \psi_t^{trans} = \left[\varepsilon_t^{ad} \quad \varepsilon_t^{prices} \quad \varepsilon_t^{lf}\right]'$$

τ_t is a vector of common stochastic trends. It includes a real stochastic trend, θ_t, and a nominal stochastic trend, β_t, which are driven by ϑ_t and ς_t, the structural (uncorrelated) real and nominal disturbances, respectively. ψ_t is the vector of all structural disturbances, and $\Phi(L)$ is a polynomial matrix, with L the lag operator. z_t is a vector of exogenous variables, and $\Gamma(L)$ is a polynomial matrix. ε_t^{ad}, ε_t^{prices} and ε_t^{lf} are disturbances (uncorrelated with the other disturbances), identified as an aggregate demand shock, a cost-push shock, and a liquidity preference shock (the identification restrictions are discussed later).

Shocks

There are two types of disturbances: those that have permanent and transitory effects on each variable of the system, called permanent shocks, and those that have only transitory effects, called transitory shocks. The former type of shocks, ψ_t^{perm}, is constituted of the real and nominal shocks, while the latter is constituted of the aggregate demand shock, the cost-push shock, and the liquidity preference shock. The number of shocks of each type is determined by the number of variables in the system and the number of cointegration (i.e. long-run equilibrium) relationships that exist between them.

Transitory and Permanent Components

The transitory component of x_t represents the temporary dynamic effects of all random disturbances of the system and exogenous variables, $x_t^{trans} = \Phi(L)\psi_t + \Gamma(L)z_t$. The permanent component is the sum of the stochastic trends and the cumulative effects of the exogenous variables, $x_t^p = A\tau_t + B\sum_{i=1}^{t} z_i$. There are two common stochastic trends, of which generating processes are assumed to be random walk with drift.

The estimation and analysis of the CTM involves (i) the determination of the degree of integration of the series, (ii) the determination of the number and estimation of the cointegration relationships, (iii) imposing economic theory-based restrictions to identify the structural shocks, (iv) performing an impulse-response analysis, and (v) variance decomposition analysis. The CTM has been estimated over the sample period 1980 Q4–2002Q3. All data are from the CEIC database.

B. Results

Unit Root Tests and Cointegration Analysis

The standard Augmented Dickey-Fuller test could not reject the presence of a unit root in all variables. Tests of cointegration have been carried out using the Johansen (1988) maximum likelihood procedure. As shown in Table A1, results indicate the existence of three cointegration relationships. However, for the three (normalized) cointegrating vectors to have any economic interpretation, one needs to impose restrictions that are provided by economic theory.

Table A1. Cointegration Test

Null Hypothesis	LR max		LR trace	
Number of Cointegrating Vectors	Statistics	5 Percent Critical Value	Statistics	5 Percent Critical Value
No constant in cointegrating vector, no deterministic trend in data				
None	**42.52**	30.04	**103.63**	59.46
At most 1	**35.75**	23.80	**61.11**	39.89
At most 2	<u>17.53</u>	17.89	**25.36**	24.31
At most 3	5.63	11.44	<u>7.83</u>	12.53
At most 4	2.20	3.84	2.20	3.84
constant in cointegrating vector, no deterministic trend in data				
None	**44.05**	76.07	**128.51**	34.40
At most 1	**38.11**	53.12	**84.45**	28.14
At most 2	**28.73**	34.91	**46.34**	22.00
At most 3	<u>13.02</u>	19.96	<u>17.62</u>	15.67
At most 4	4.59	9.24	4.59	9.24

Source: IMF staff estimates.
Notes: Figures in bold indicate the rejection of the null hypothesis.

Because the study aims at analyzing deflation in a highly open economy with well developed financial markets, theories such the Quantity Theory of Money (QTM), Purchasing Power Parity (PPP), and Arbitrage Relationship between output and real stock prices provide restrictions that are useful for understanding the long-run determinants of the variables of the system, especially the price level. The QTM implies a cointegrating vector that includes output, money and the price level (and a measure of opportunity cost of holding money), with an income elasticity that has to be estimated and opposite unitary coefficients on money and the price level. The PPP implies a cointegrating vector which includes the domestic and foreign price levels, with associated coefficients equal to one and minus one, respectively. Although the cointegrating vector implied by the arbitrage relationship does not assign a specific value to the coefficient associated to output and real stock prices, it does suggest a positive relationship between them.

As shown in Table A2, the null hypothesis of binding theoretical restrictions can not be rejected at any standard level, and the estimated coefficients are consistent with the predictions of the theories mentioned above.

Table A2. Test of Theoretical Cointegrating Vectors

	Money Demand	PPP	Arbitrage
y_t	-1.7 (0.05)		1
f_t			-0.49 (0.03)
m_t	1		
p_t	-1	1	
ep_t^*		-1	
Likelihood Ratio Test, $\chi^2(3)$	4.98		

Source: IMF staff estimates.
Note: Standard errors in parenthesis.

Identification of Shocks

The model is identified using the restrictions implied by the long-run equilibrium relationships, and long-run and short run restrictions à la Blanchard-Quah. The existence of three cointegration relationships implies that the system of five variables has two common stochastic trends that are driven by two structural shocks, which have a permanent effect on these variables.

The two permanent shocks are considered as a real (productivity/supply) and a nominal (change in average money supply/price convergence). The permanent real shock could possibly include productivity shocks, tax reforms, changes in labor market conditions, and more generally measures/events that affect the supply side of the economy. The permanent nominal shock could include all shocks that lead to (unanticipated) changes in the money stock relative to what is required to finance long-run real output, changes in the trend in inflation expectations, and permanent changes due to price convergence. In order to separately identify these two permanent shocks, one restriction needs to be imposed. The long-run neutrality of money, which implies that the permanent nominal shock does not affect real GDP has been imposed. This is sufficient to ensure a zero-effect of the permanent nominal shock on all real variables in the long run.

The remaining three stochastic processes of the five variable system are driven by transitory shocks, of which identification requires the imposition of 2 restrictions. The restrictions on the effects of the transitory shocks on the short-run dynamics of the variables exploit information about lags in the propagation mechanism, sources of rigidities (e.g. contracts length), and other stylized facts. The following two restrictions have been imposed:
(i) cost-push shocks do not have an immediate impact on output; and (ii) liquidity preference shocks do not have an immediate impact on output and domestic prices.

Although these restrictions can not be tested since the model is exactly identified, their accuracy can be assessed through the analysis of the impulse response functions.
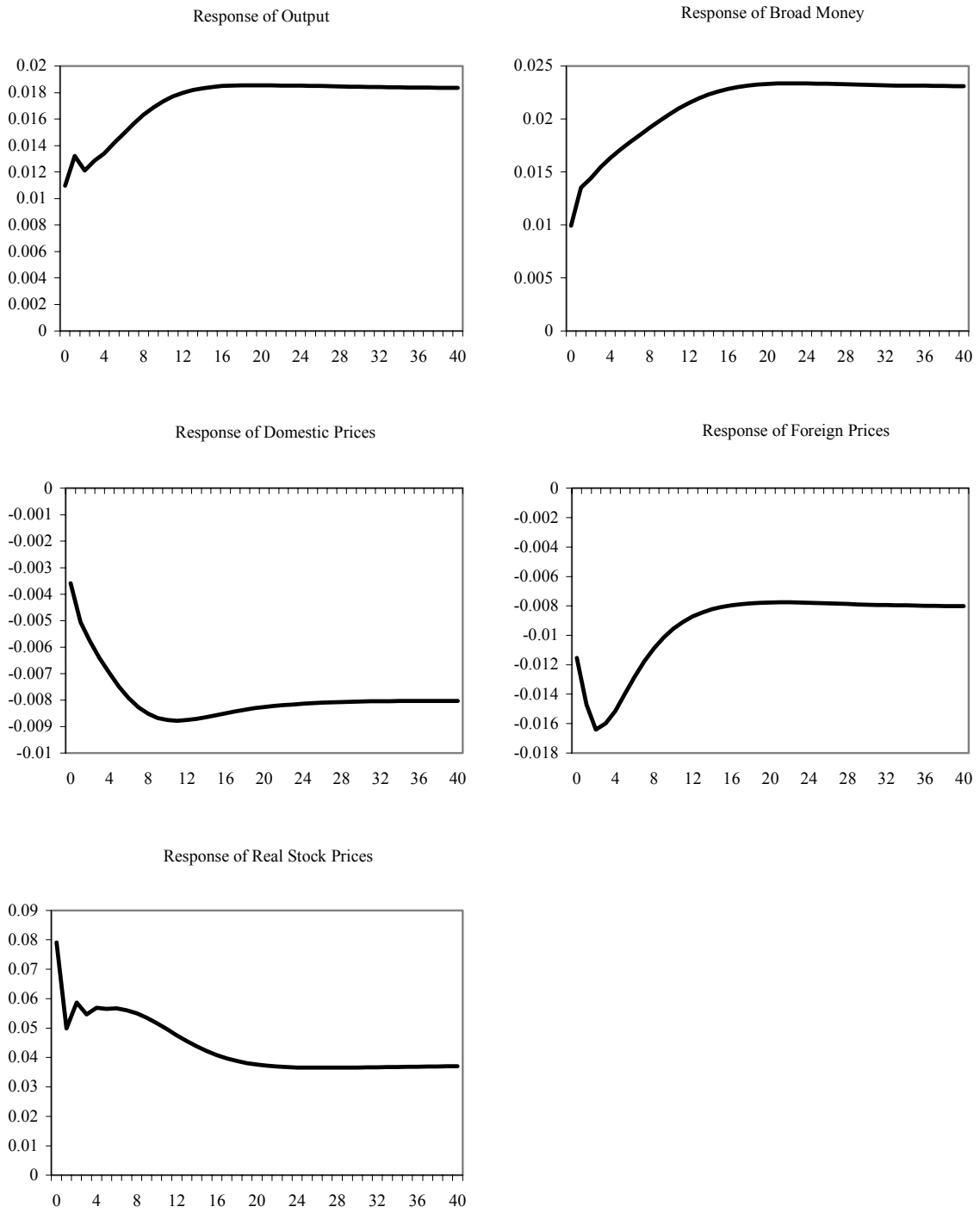
Impulse Response Analysis

Figure A1–A5 present the responses of the variables to the five shocks. Overall, all responses corroborate the predictions of standard economic theory, which provide support to the identifying restrictions that have been imposed.

A productivity shock leads to a permanent increase in output, real stock prices, money supply, and a permanent decline of the price level. Note that the implied response of real cash balances (response of money minus that of the price level) indicate a permanent increase. A nominal shock (permanent change in the money supply/price convergence) has transitory but persistent effects on real variables and permanent effects on all nominal variables. Output increases temporarily above its permanent level (after a temporary fall for two quarters), as well as real stock prices which fall after eight quarters following the increase in the price level and decline in broad money. The positive effects of the liquidity preference shock on output are short-lived and reversed after six quarters. This shock leads to a temporary gradual increase in the price level and a decline in broad money. A cost-push shock reduces temporarily output, real stock prices and broad money. After an aggregate demand shock, output and the price level increase, while real stock prices and broad money decline.

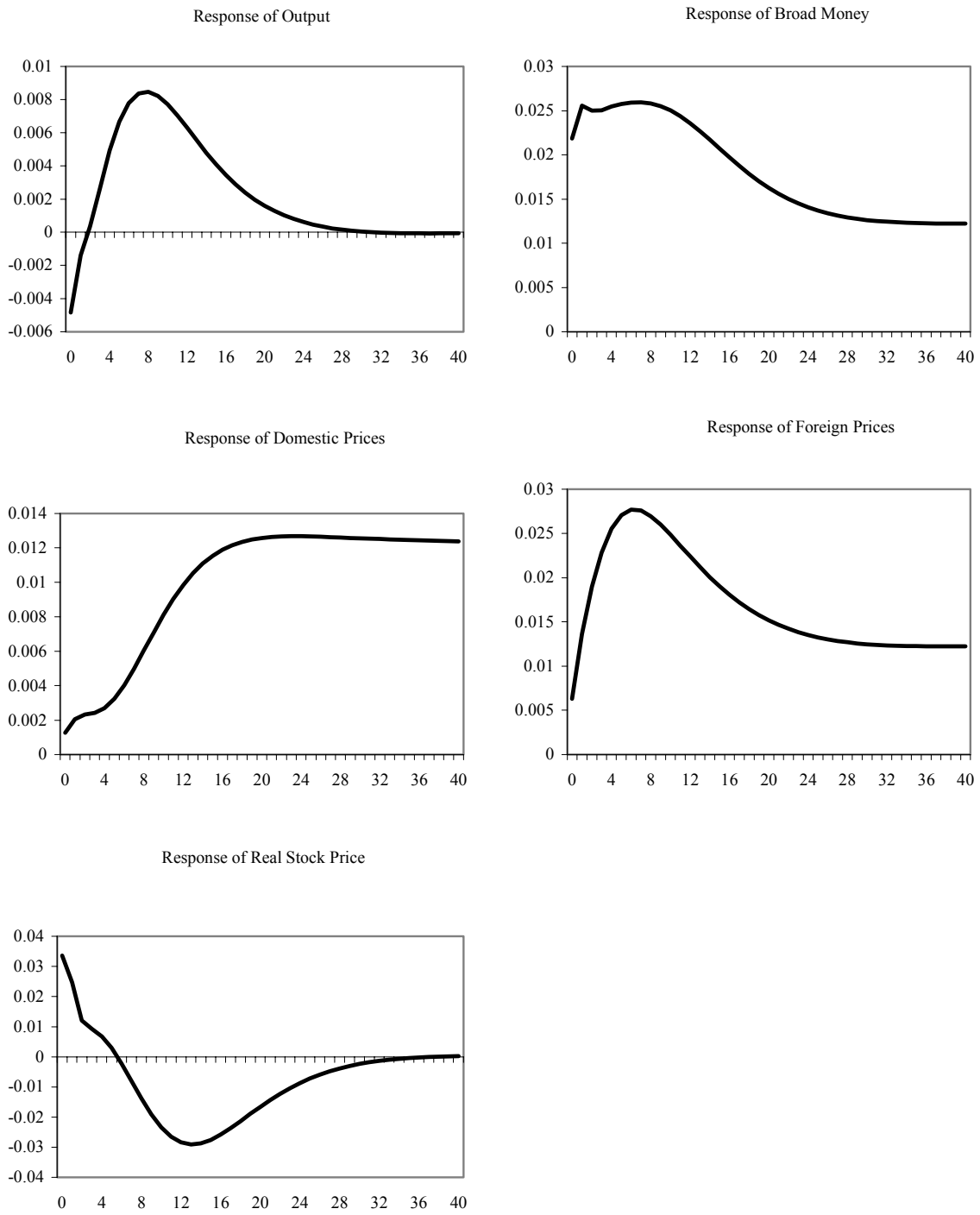**Permanent and Transitory Components**

Figures A6–A7 present the actual levels of the variables of the system and estimates of their permanent and transitory components. The estimates help, for example, to identify periods during which deflation has been accompanied with increased productivity (permanent component of output), insufficient amount of money chasing real goods and services (transitory component of broad money), or negative swings in investors' sentiment.
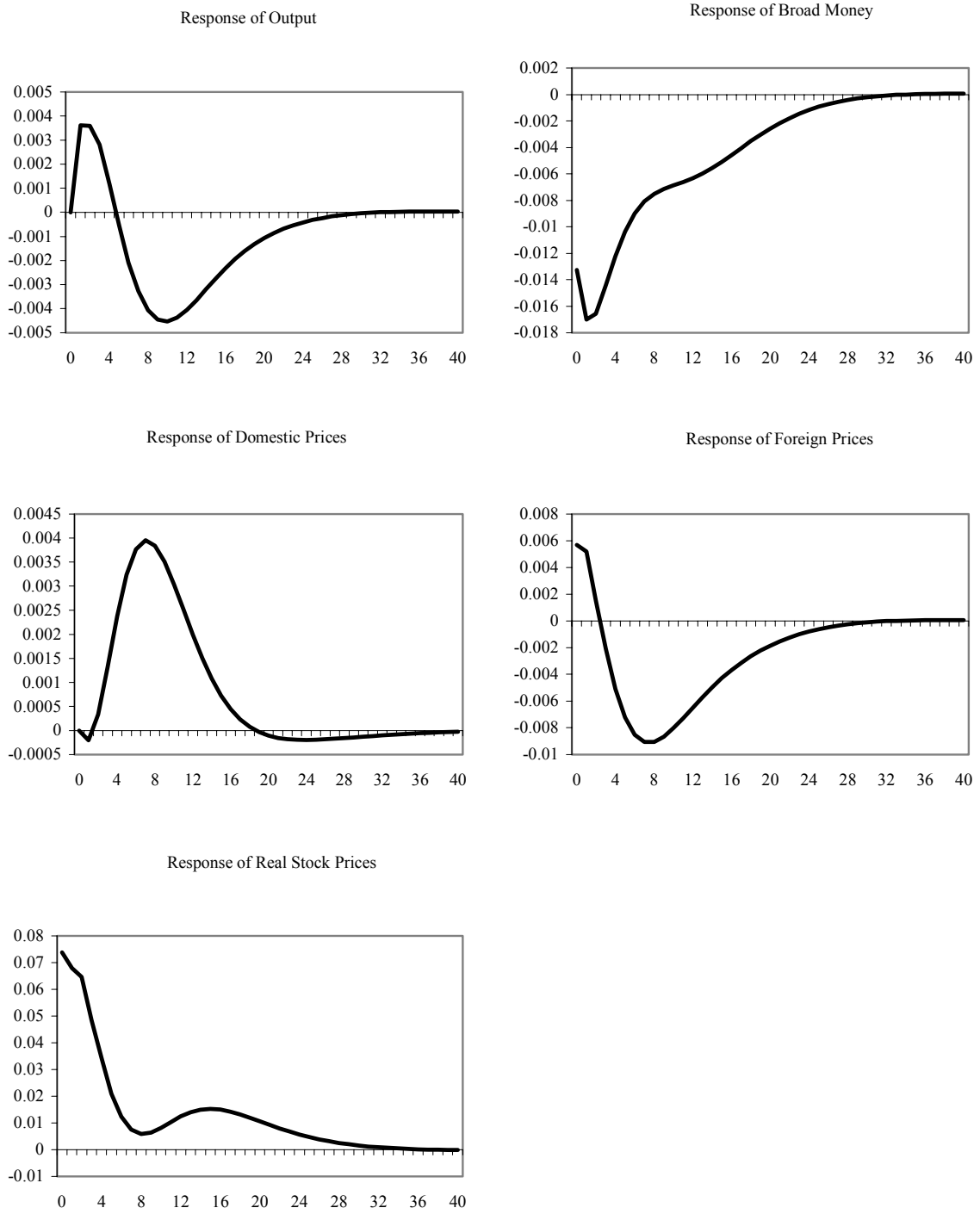
Figure A1. Productivity Shock

Response of Output

Response of Broad Money

Response of Domestic Prices

Response of Foreign Prices

Response of Real Stock Prices

Source: IMF staff estimates.

Figure A2. Permanent Nominal Shock

Response of Output

Response of Broad Money

Response of Domestic Prices

Response of Foreign Prices

Response of Real Stock Price

Source: IMF staff estimates.

Figure A3. Liquidity-Preference Shock

Response of Output

Response of Broad Money

Response of Domestic Prices

Response of Foreign Prices

Response of Real Stock Prices

Source: IMF staff estimates.

Figure A4. Cost-Push Shock

Response of Output

Response of Broad Money

Response of Domestic Prices

Response of Foreign Prices

Response of Real Stock Prices
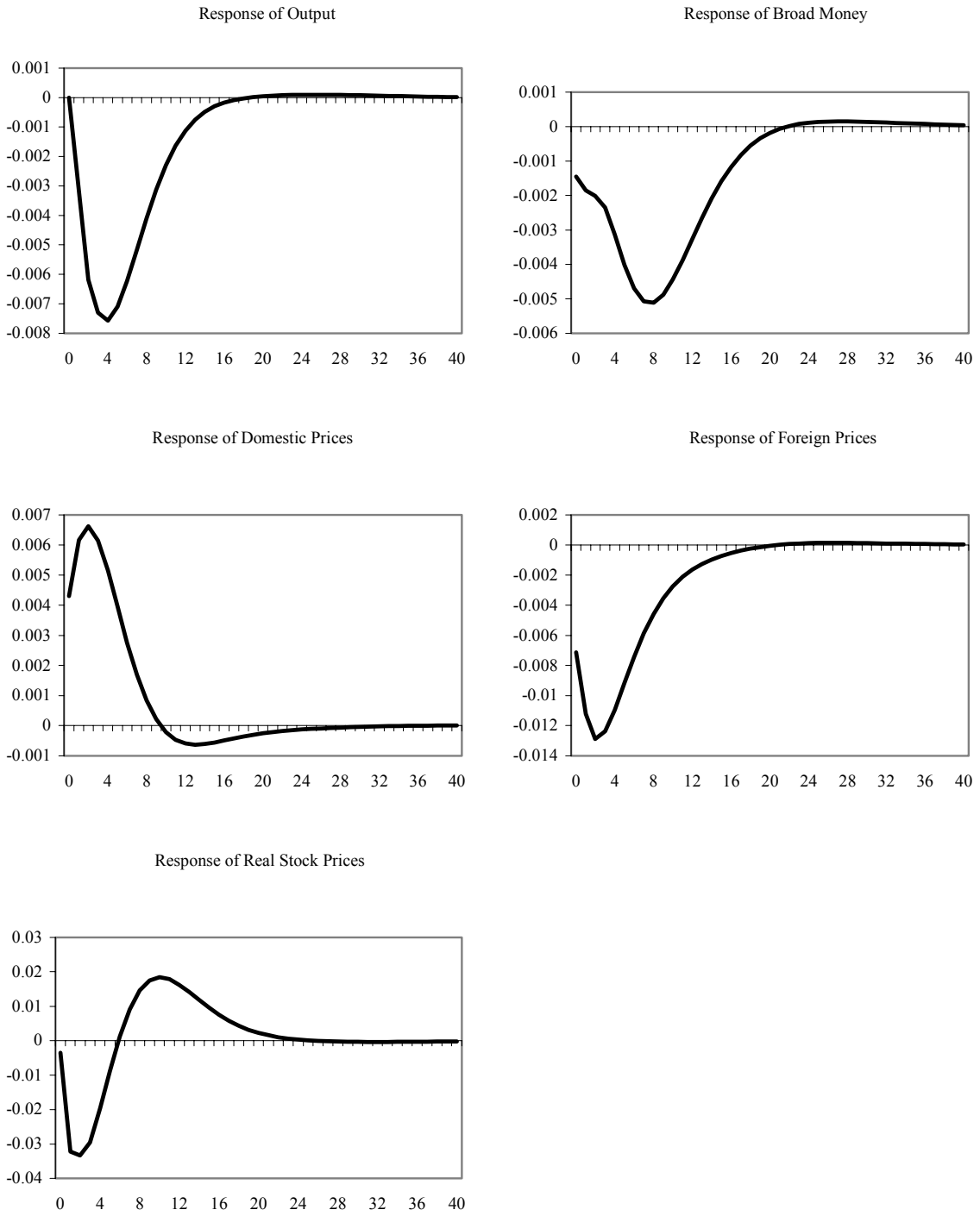
Source: IMF staff estimates.

Figure A5. Aggregate-Demand Shock

Response of Output

Response of Broad Money

Response of Domestic Prices

Response of Foreign Prices

Response of Real Stock Prices
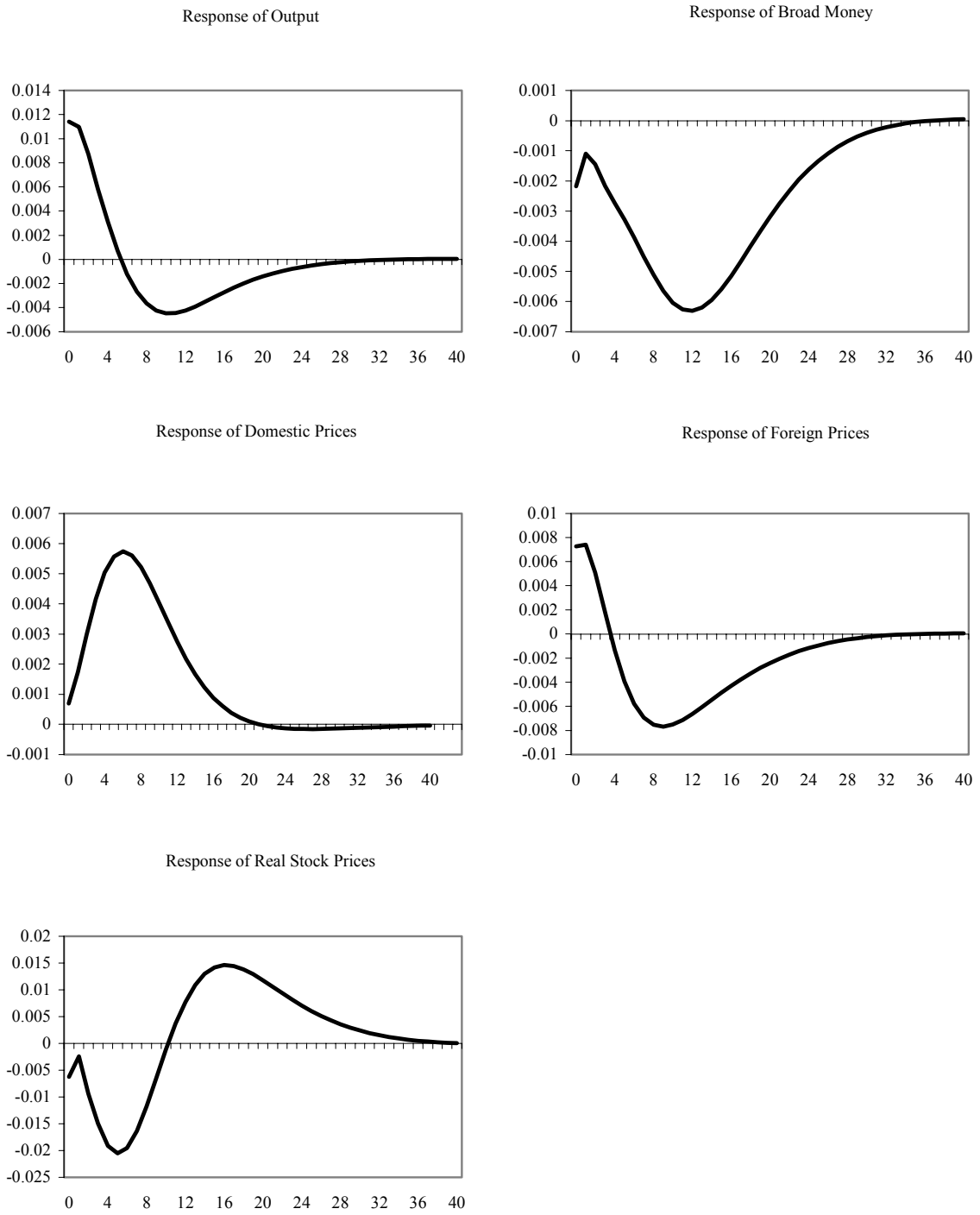
Source: IMF staff estimates.

Figure A6. Domestic and Foreign Prices

Domestic Prices: Actual and Permament and Transitory Components

Foreign Prices: Actual and Permanent and Transitory Components
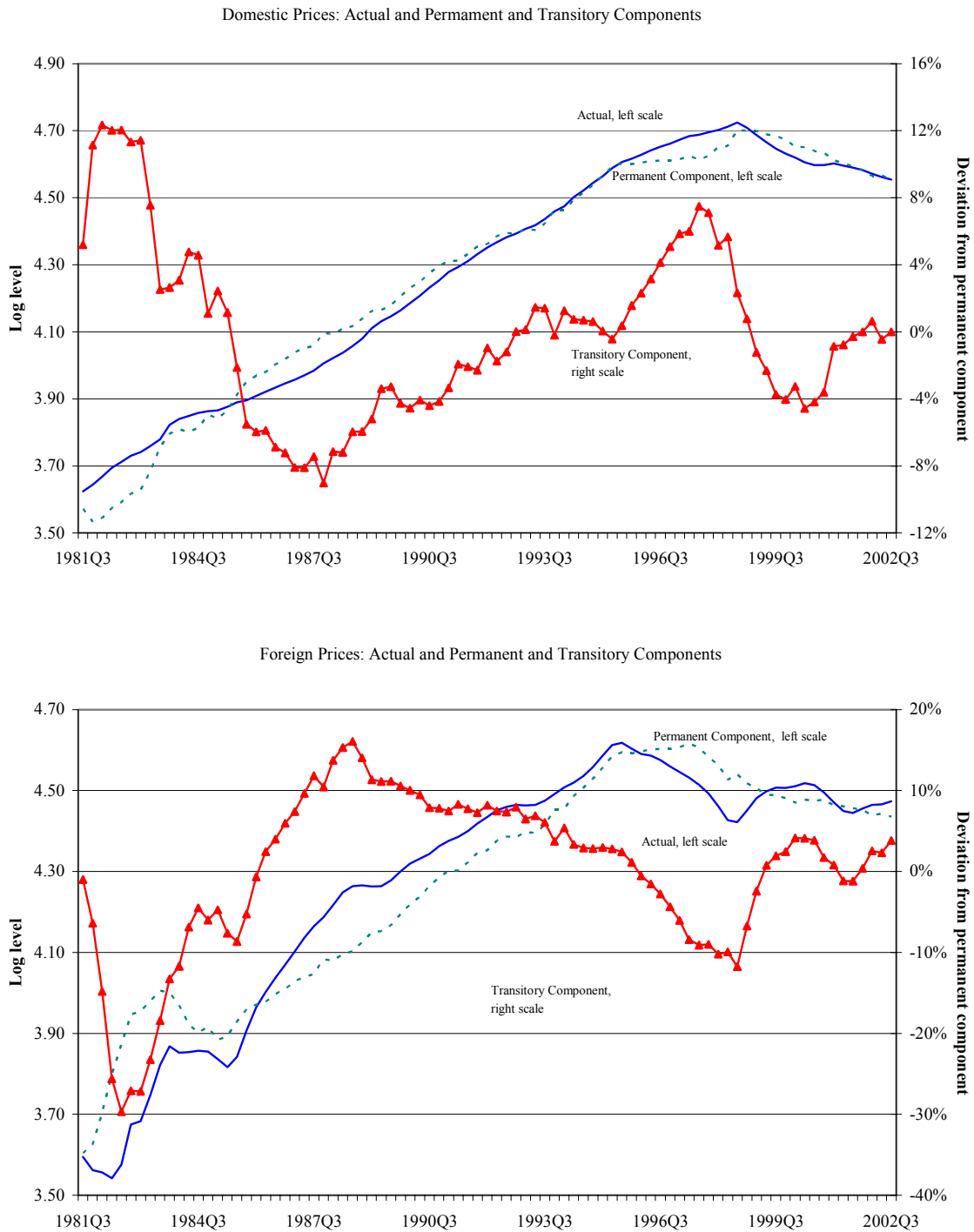
Source: IMF staff estimates.

Figure A7. Output, Real Stock Prices, and Broad Money

Output: Actual and Permanent and Transitory Components

Real Stock Prices: Actual and Permanent and Transitory Components

Broad Money: Actual and Permanent and Transitory Components
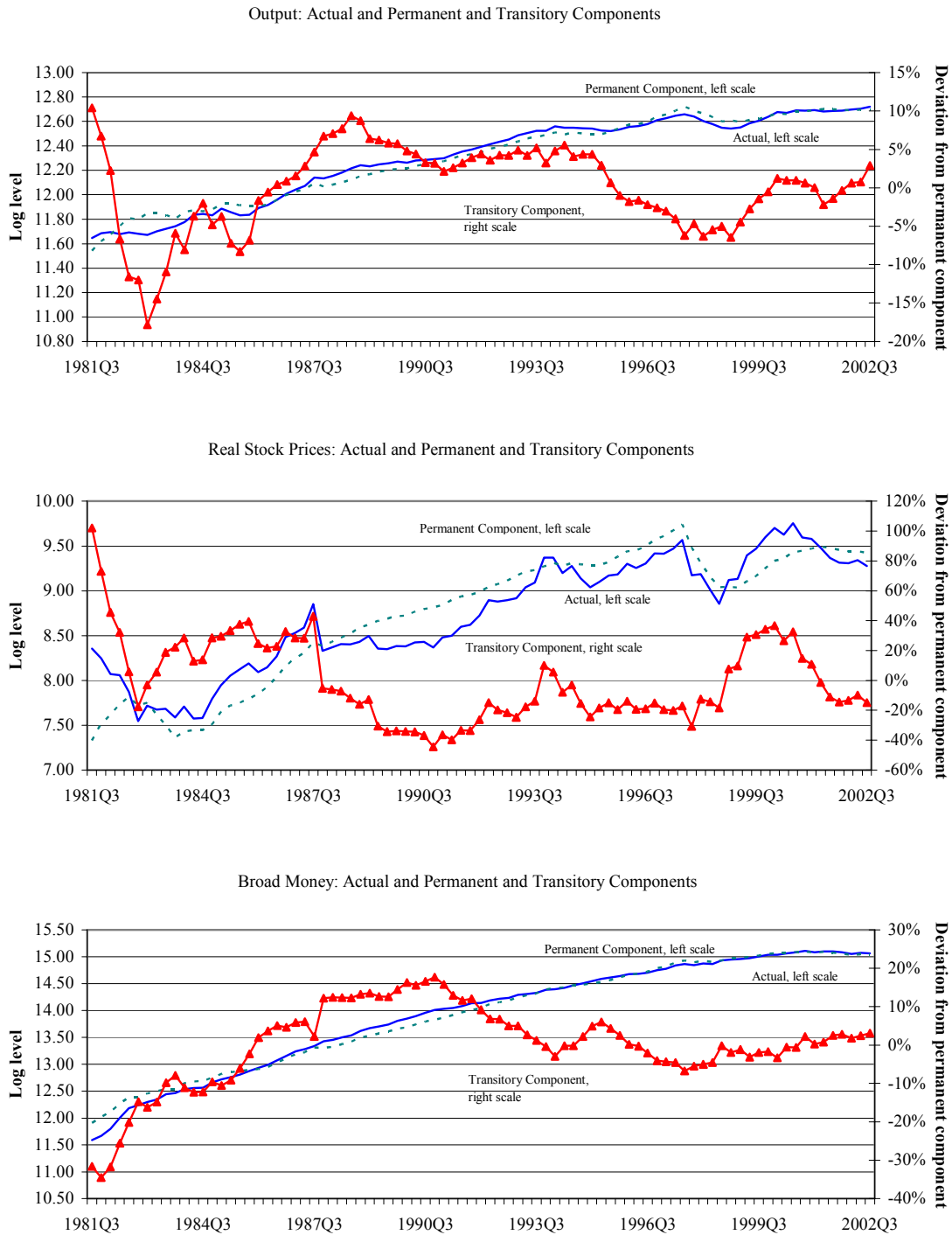
Source: IMF staff estimates.

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