Asymmetric Effects of Monetary Policy Shocks

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Abstract

This paper examines, using small-scale vector autoregression models, the extent to which monetary policy shocks have asymmetric effects on the cyclical component of output, inflation, and the rate of exchange rate depreciation. It begins by reviewing potential sources of asymmetry. It then discusses three approaches to testing for the presence of asymmetric effects in the transmission of monetary shocks: the first relies on the sign of the output gap, the second on the initial level of of the monetary policy instrument itself, and the third on the initial level of inflation. Estimation results, using quarterly data, are presented for Korea, Malaysia, the Philippines, and Turkey. Impulse response functions indicate that monetary policy shocks (measured as innovations in, alternatively, the money market rate, the discount rate, and the monetary base) have significant asymmetric effects which vary across instruments and countries. However, some of the typical "puzzles" identified in recent VAR studies are also present in these results.

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Contents

1 Introduction

In recent years macroeconomists have used a variety of modeling approaches to analyze empirically the impact of monetary policy on aggregate output, inflation, and asset prices. These approaches include reduced-form equations, small- and large-scale structural models, and standard or structural vector autoregression models (VARs), which have proved to be particularly popular in industrial and developing countries alike.[1] At the same time, however, it has been recognized that standard applications of some of these tools are not well suited for capturing the nonlinear responses—in the form of either asymmetric responses or regime switches—that theoretical models suggest may be pervasive. Indeed, some recent empirical studies (focusing mostly on industrial countries) have suggested that monetary policy may have "ratchet" or asymmetric effects on macroeconomic variables. Assessing the extent to which the economy's response to monetary policy actions involves nonlinearities has important implications for macroeconomic management: asymmetric effects may imply, for instance, that monetary policy is not an effective policy instrument to stimulate output in recessions and that instead fiscal policy is more appropriate.[2]

The purpose of this paper is to explore, using small-scale VARs, the extent to which asymmetric effects in the monetary transmission process (defined and measured in alternative ways) can be estimated. Section II identifies various channels through which such effects may arise and reviews some of the available empirical evidence. Model specification and estimation methodology are discussed in Section III. Specifically, three approaches are considered to test for the presence of asymmetries in the monetary transmission mechanism. The first, following Macklem (1995), depends on whether the output gap is initially positive or negative. The second depends on the initial level of the policy instrument itself, and the third depends on the initial level of inflation—a potentially important "conditioning" variable in developing countries where inflation bursts have been frequent and costly in

[1]See, for instance, Fung and Kasumovich (1998), Sims (1992), Christiano, Eichenbaum, and Evans (1996), Clarida and Gertler (1996)), Kim and Roubini (2000), and Leeper, Sims and Zha (1996). See also Beaudry and Saito (1998) for a criticism of the restrictions used to identify monetary policy shocks in some of these studies.

[2]Note that some analytical models predict nonlinear dynamics taking the form not only of asymmetric responses to shocks but also regime switching; see, for instance, Azariadis and Smith (1998).

real terms. Section IV presents estimation results using quarterly data for a group of four developing countries: Korea, Malaysia, the Philippines, and Turkey. Section V provides an analysis of impulse response functions associated with monetary policy shocks, measured as innovations in, alternatively, the money market interest rate, the official discount rate, and the growth rate of the monetary base. The choice of these three alternative variables as indicators of monetary policy is motivated by the prevailing controversy regarding the proper way of measuring monetary policy shocks. As discussed in more detail below, it has been argued that innovations in short-term interest rates, for instance, may not be an appropriate measure of the monetary policy stance because they mix together shifts in the supply of liquid reserves to the financial system initiated by the monetary authorities with shifts in the private sector demand for loans and the supply of deposits. The use of alternative measures of the monetary policy stance is a way to account (at least partially) for the difficulty of identifying the proper instrument of monetary management and provides a robustness check on the results. Both symmetric and asymmetric results are considered in each case, and both the direction and the size of shocks are compared across specifications. The concluding section summarizes the main results of the analysis and discusses some possible extensions.

2 Asymmetric Effects of Monetary Policy

From an analytical standpoint, a number of alternative macroeconomic models are capable of predicting an asymmetric effect of monetary policy shocks on aggregates such as output, prices, and the exchange rate. A common approach is the so-called Keynesian interpretation, which relates the source of asymmetry to the fact that nominal wages are less flexible downward than upward, generating thereby a "kinked" aggregate supply curve—and thus implying that negative (contractionary) monetary shocks are asymmetric. In addition, models that emphasize the "credit view" of monetary policy argue that negative money supply shocks have adverse effects on the banking system and thus on economic activity, with no corresponding effects when shocks are positive. These sources of asymmetry, as well as a variety of others, are reviewed in the first part of this section. The second part provides an overview of the existing empirical evidence on the asymmetric effects of monetary policy, which pertains mostly to industrial countries.

2.1 Sources of Asymmetry

2.1.1 Confidence Factors

The first possible source of asymmetry in the impact of monetary policy relates to confidence factors. The argument is essentially that confidence in the economy's prospects may change over the course of the business cycle and may generate asymmetric effects—for instance if consumers and firms are more pessimistic during recessions than they are optimistic during expansions, or if the weight attached to immediate relative to future prospects increases during recessions. The loss of confidence during a recession can make monetary policy (in the form of, say, a cut in interest rates) less effective: if consumers and firms worry more about the overall economic outlook and the economy's likely direction in a downturn, they will pay less attention to interest rates during recessions than during booms. For instance, if uncertainty about future profitability rises during recessions or if concerns about future profitability increase during "bad" times, firms will invest less—even if monetary policy becomes more expansionary. in this particular case the reason may also be related to the fact that there is an "option value" associated with waiting for the uncertainty to dissipate, at least to some extent (Dixit and Pindyck (1994)). Output will therefore become less sensitive to changes (that is, cuts) in interest rates when the economy is operating below capacity.

2.1.2 Nominal Wage Stickiness

An alternative source of asymmetric effects is the Keynesian interpretation alluded to earlier, which is based on the view that wages are less flexible downward than upward. If nominal wages are upwardly flexible but downwardly sticky, positive monetary shocks will be neutral, whereas negative money supply shocks will be non-neutral. This asymmetry in wage and price adjustment may result from a variety of sources. First, workers may oppose *nominal* wage cuts, implying that downward movements in real wages can be induced only by higher inflation. At low initial rates of inflation, this may imply considerable asymmetry. Second, workers may resist downward adjustment to *real* wages, but at the same time they may favor (as firms may possibly do) quick adjustment of wages on the up side; as a result, wages may be quicker to adjust upward than downward. This rapid adjustment in wages may be the result of efficiency wage considerations, which imply that firms may find it in their best interest to raise wages quickly in response to a shock in order to maintain or improve productivity (by promoting commitment and raising morale) and to reduce turnover costs (by reducing quits).

2.1.3 Capacity Constraints

An alternative source of asymmetry results from the possibility that expansions can be constrained by the existing production capacity, due to short-run shortages of labor and (perhaps more often) physical capital. As a result, as excess demand increases and the economy approaches full capacity, an expansion in aggregate demand induced by lower interest rates has increasingly smaller effects on output and correspondingly larger effects on prices. Eventually, when full capacity is reached, further increases in aggregate demand only lead to higher prices. The growing evidence on nonlinearities in the Phillips curve in industrial countries (Laxton, Meredith, and Rose (1995)), and more recently also in developing countries (Agénor (2000)), provides support for this type of asymmetric effects.

In a small open economy context, the assumption of a convex short-run aggregate supply of *nontradable* goods helps to explain an asymmetric relative price effect of monetary policy (Macklem (1995)). If capacity constraints limit the short-run response of output of nontradables following an increase in demand induced by an expansionary monetary policy, there may be asymmetry in the response of the real exchange rate. The reason is that with a pegged exchange rate, and given that the world price of tradables is determined on world markets, changes in the real exchange rate will depend essentially on changes in the price of nontradables. An expansionary monetary shock will increase demand for nontradables; this will lead to an increase in the relative price of nontradables, that is, the real exchange rate will appreciate. This appreciation will be larger when output of nontradables is close to capacity output, compared to when it is significantly below it.

2.1.4 Menu Costs and Asymmetric Price Rigidities

Monetary policy may also have asymmetric effects on output and inflation if prices are less flexible downward or upward due to the existence of menu costs. Caballero and Engel (1992, 1993), Ball and Mankiw (1994), and Tsiddon (1993) have developed conceptually similar models in which the existence of menu costs can lead to asymmetric price adjustment. Ball and Mankiw

(1994), for instance, dwelling on the New Keynesian approach to macroeconomics, provide explicit microeconomic foundations for asymmetry in a model where (monopolistically competitive) firms can costlessly set prices every second period, but are subject to a menu cost if they do change prices between periods. If firms face menu costs in changing prices, small deviations of actual prices from desired prices will not result in price adjustment, whereas larger deviations that exceed some threshold will. In the presence of menu costs, optimizing firms will adjust prices in response to trend inflation at discrete intervals, and actual prices between adjustments will be falling relative to desired prices.[3] In this setting, prices will tend to be more flexible upward than downward if there is trend inflation, because in this case positive shocks are more likely to trigger price adjustments than are negative shocks of the same size. The reason is that in the face of negative shocks, the typical firm is less likely to pay the menu cost and change its actual price because some of the price adjustment will come about as a result of inflation. Positive shocks, by contrast, cause desired relative prices to rise at the same time as actual relative prices are being eroded by inflation. A key feature of the model is thus that agents in the economy face an inflationary environment. With "core" inflation, a small negative change in demand (resulting from, say, higher interest rates) may induce firms to take no action because inflation automatically leads to a downward change in relative prices, even with unchanged nominal prices. Hence, if the "optimal" price does not differ too much from the preset price, it may not be individually rational to pay the menu cost occurred when changing prices between periods. A positive change in nominal demand, by contrast, is much more likely to trigger price adjustment because of the existence of inflation that magnifies the change in demand in case of no change in prices. Tsiddon (1993) obtained a similar result in a model with comparable features.

Another important result derived by Ball and Mankiw (1994) is that the degree of asymmetry in the output response to a monetary shock is also positively related to the *size* of the shock. The asymmetric response does not exist at zero "core" inflation and becomes more pronounced at a higher rate of inflation. Caballero and Engel (1992) and Tsiddon (1993) also found that the degree of asymmetry increases with the inflation rate, as do Ball

[3]Inflation here is taken as given in analyzing an individual firm's pricing decisions. Ball and Mankiw (1994), however, determined inflation endogenously as a function of these decisions.

and Mankiw. In the Caballero-Engel model, for instance, the argument is that higher inflation implies that firms are typically closer to the barrier that triggers price increases than to the one that triggers price reductions. These results have important implications for testing for asymmetric effects and are further discussed below.[4]

The New Keynesian literature on menu costs suggests also another reason why the magnitude of shocks may matter for asymmetric effects, that is, why "big" and "small" shocks to nominal demand can have different effects (Ravn and Sola (1996)). The implication of this is that there is a nonlinear relationship between nominal demand changes and their effects on output. In models with menu costs, such as Blanchard and Kiyotaki (1987), and many others, a strategy of keeping prices constant so as to avoid the menu cost can be optimal in response to a small change in nominal demand. The reason for this is that the loss associated with this strategy is second order. Hence, "small" shocks, as defined relative to the size of the menu costs, are not neutral. However, in the face of big changes in nominal demand (or, by implication here, large changes in the monetary policy instrument), both first- and second-order costs will be incurred if the strategy of keeping prices fixed is followed, and hence firms are likely to find it optimal to neutralize demand changes by adjusting nominal prices. Therefore, the prediction of such models is that small shocks have real effects, whereas big shocks are neutral. Naturally, the distinction between these two types of shocks is conditional upon a number of variables, including the size of the menu cost associated with changing prices, and the strength of real rigidities (see Ball and Romer (1990)).

2.1.5 Credit Constraints

Yet another potential source of asymmetry in the monetary transmission mechanism relates to credit constraints, which are more likely to bind during recessions. A monetary policy tightening can lead to credit constraints if banks are unwilling to lend to riskier borrowers when market rates are high, as implied by adverse selection models of the credit market of the Stiglitz-Weiss type (see, for instance, Jaffee and Stiglitz (1990)). A rise in policy

[4]Demery and Duck (2000) extend the Ball-Mankiw model to allow for long-term growth and some elementary dynamics. These extensions, however, preserve the model's main prediction, namely, that nominal demand shocks have non-linear and asymmetric output effects in inflationary economies.

interest rates leads to higher market interest rates and higher deposit rates; banks, however, may be reluctant to pass on to borrowers the higher cost of funds that they face by raising loan rates. The reason is that because higher loan rates increase borrowers' debt burden and may raise the risk of bankruptcy, only riskier borrowers are willing to borrow. To avoid the deterioration in the quality of their loan portfolio, banks may opt to ration credit.

Thus, by raising market interest rates, a contractionary monetary policy (aimed at slowing a fast-growing economy) may lead to a tightening of credit constraints, thereby magnifying the impact of the initial shock on borrowing and spending. Conversely, an expansionary monetary policy may relax credit constraints by lowering market rates. Relaxing borrowing constraints, however, may not necessarily lead to higher demand for loans and higher spending if the economy is already slowing (which may explain the expansionary policy in the first place). Put differently, if credit constraints bind only when monetary policy is contractionary and the demand for credit is strong because activity is high, then a tight policy will be more powerful than an expansionary policy, imparting therefore an asymmetric bias to monetary policy actions.

The foregoing discussion dwells essentially on the interaction between credit constraints and the demand for loans to rationalize the existence of asymmetric effects of monetary policy. Credit constraints may also lead to asymmetric responses by affecting consumption behavior, as for instance in the model of Jackman and Sutton (1982). In that model, higher interest rates force constrained consumers to reduce spending by the full amount that their loan payments increase. Lower rates relax the constraint, but spending increases less than proportionately because consumers spread out their spending across time, as implied by the permanent income hypothesis. Another mechanism through which credit constraints can lead to asymmetry is through net worth effects, along the lines of Gertler (1988) and Bernanke and Gertler (1989). In that model, firms may be credit constrained because of low collateral. When firms are fully collateralized, and hence unconstrained, sharp declines in investment spending are more likely than sharp increases. The reason is that credit constraints are more likely to bind during recessions when net worth is low–perhaps as a result of a drop in asset prices. When credit constraints are binding, monetary policy operates essentially through quantity constraints and less through conventional interest rate channels; as a result, the effects of monetary shocks may be more pronounced in downturns than in upturns.

2.2 Empirical Evidence

An important implication of the foregoing discussion is that alternative analytical models have different implications for the type of asymmetry that characterizes monetary policy. Rigorous testing of these alternative explanations in an attempt to discriminate among them is, however, beyond the scope of this paper. More modestly, this paper attempts to compare three different ways of measuring asymmetric effects, as discussed in the next section. Before doing so, however, a brief review of the existing empirical literature on the asymmetric effects of monetary policy is provided, focusing in particular on the contributions of Cover (1992), Balke (2000), Karras (1996), Karras and Stokes (1999), Macklem (1995), Morgan (1993), Ravn and Sola (1996), and Shen and Chiang (1999).

Existing empirical studies (which focus only on industrial countries) have focused on essentially three types of variables to measure and test for the presence of asymmetric effects: the *sign* of monetary policy shocks (defined either through residuals from an estimated policyrule, or as reduced-form innovations in a VAR); the absolute *size* of monetary policy shocks (defined as residuals); and the initial *magnitude* (or size) of another variable, such as the output gap, for a given level of the monetary policy instrument. In one of the early studies, Cover (1992) developed a two-stage approach involving the estimation of a money supply process and an output equation; positive and negative residuals from the money growth equation were entered separately in the output equation and their significance tested. He found that for the United States negative money supply shocks significantly reduced output, whereas positive shocks were not significant. Morgan (1993) used also a two-step approach but estimated a policy reaction function for the Federal funds rate, viewed as a more accurate measure of the stance of monetary policy. He found that a positive innovation in the Federal funds rate has an asymmetric effect on output; increases in the funds rate tended to have a significant adverse effect on activity, whereas reductions proved to be insignificant. Along the same lines, Karras (1996) found that in industrial countries in general the effects of unanticipated money supply and interest rate shocks on output also tended to be asymmetric; unexpected monetary contractions (or increases in policy interest rates) tended to reduce output by more than monetary expansions (or reductions in interest rates) tended to raise it. More recently, Karras and Stokes (1999) argued that Cover's (1992) regression model is a special case of a more general model that is capable of distinguishing between two sets of factors consistent with the asymmetric response of output to monetary shocks: a convex aggregate supply, and the "credit view", as discussed earlier.[5] In addition, they found that asymmetries in the effects of money supply shocks on output are intensified by increases in the rate of inflation, as suggested by menu cost models of the Ball-Mankiw variety. Caballero and Engel (1992), in a study of 37 low and moderate inflation countries, also found that the output effects of money demand shocks are asymmetric for a number of countries and depend on the level of inflation. As inflation rises across countries, the impact on output of unexpected increases in spending falls, as predicted by their model and Ball and Mankiw (1994).[6] Thus, the degree of asymmetry tends to increase with the inflation rate, as indicated earlier.[7]

A problem with the results obtained by Cover (1992) and others adopting a similar approach is that their robustness with respect to the single-equation estimation technique used and the way monetary shocks are estimated (as residuals from a money growth equation) is open to question. An alternative technique that somewhat alleviates these criticisms is a VAR-based approach. Macklem (1995) was one of the first to use such an approach for Canada. He found evidence of important asymmetries in the effect of monetary policy shocks, measured as innovations in the yield differential between short- and long-term interest rates. Impulse response analysis indicated that a fall in interest rates that is implemented when current output is below its trend had a quicker and larger impact on output, and a smaller and more delayed effect on prices, than does the same policy implemented when output is above potential. Similarly, the exchange rate response to a monetary shock was larger when output was initially below trend, that is, when the output gap was negative. The first result is not consistent with the "confidence view"

[5]They also found that the effects of money on prices are symmetric (which is consistent with both sets of factors being operative at the same time), that consumption responds symmetrically to money, and that the response of fixed investment is characterized by asymmetries very similar to those that affect output.

[6]They studied, however, the effect of spending changes in general, not just changes in monetary policy.

[7]As another example of a "conditioning" variable, Balke (2000) found that the effect of monetary growth on output in the United States was stronger when credit market conditions exceeded a certain threshold.

described earlier, which predicts that interest rates cuts in a recession are likely to have a smaller effect on output (in absolute terms) than a comparable increase in an expansion.

Finally, the empirical research on the asymmetric effects of monetary policy based on the *size* of monetary shocks—that is, whether the magnitude of, say, changes in interest rates may have different effects on output or inflation—has been fairly limited. In one of the few studies available. Ravn and Sola (1996) found that there are asymmetric effects associated with small and large changes in nominal demand; this nonlinear relationship is such that large shocks are neutral but small shocks have real effects. They argued that their findings provide support for the menu-cost models discussed earlier, compared to the traditional Keynesian asymmetric view. The next section, which extends Macklem's (1995) approach, will account not only for the sign of the initial output gap but also for the initial size of policy shocks and the initial level of inflation.

3 Model Specification and Methodology

Given the focus here on short-run dynamics, a standard VAR approach is used to analyze the potential asymmetric effects of monetary policy shocks on key macroeconomic variables. The advantages and limitations of standard VARs are well known.[8] In particular, the results of VARs are sensitive to specification choice and identifying assumptions. However, robustness of the results is tested below by looking at three alternative ways of measuring monetary policy innovations.

3.1 Specification

The point of departure of my analysis of the asymmetric effects of monetary policy is the VAR-based approach proposed by Macklem (1995). I first define a "core" VAR consisting of the cyclical component of output, inflation, the

[8] An alternative approach would have been to use a structural VAR, along the lines of, for instance, Fung and Kasumovich (1998) and Smets (1997). However, as is well known, a problem with structural VARs is that the results can be contingent upon the choice of specific identifying (long-run) restrictions; they may therefore lack robustness. For a more detailed discussion, see Cooley and Dwyer (1998), Faust and Leeper (1994), and Sarte (1999).

rate of nominal exchange rate depreciation, and the money market interest rate. In this core VAR, innovations in the money market rate are used as the indicator of monetary policy. As is now well recognized, this approach may not be appropriate if the central bank lacks the instruments or tools needed to target open-market interest rates with sufficient precision. In that case, short-term innovations in money market rates may reflect not only policy innovations but also non-policy factors, such as shifts in the demand for (excess) liquid reserves by commercial banks. If shocks to the money market rate reflect non-policy factors, then measured impulse responses to money market rate innovations will no longer be adequate estimates of the effects of monetary policy shocks on output, inflation and the exchange rate. Put differently, only if monetary policy far outweighs all excluded variables in terms of explaining interest rates would statistical inference be robust. But because this proposition is hard to defend from either theory or empirical research, inferences about policy could be very sensitive to specification and omitted variable problems.[9]

I also define and use an "augmented" VAR model, in which I add to the variables included in the "core" model either the official discount rate or the rate of growth of the monetary base. There is one practical reason for doing so: for the countries considered and the sample period selected, there are times during which repos and open-market operations did not exist or were not conducted intensively, so that money market interest rates may not be a good proxy for monetary policy throughout the estimation period. The use of alternative measures allows an assessment of the robustness of the results. Of course, this approach is not without problems; using changes in the money stock may not be adequate either because in practice the growth rates of monetary aggregates depend on a variety of non-policy factors, such as inflation-induced changes in money demand, or movements in supply due to changes in bank behavior.[10] Changes in velocity brought about by financial innovation, deregulation, and other factors, for instance, may significantly hamper the use of money growth rates alone as an indi-

[9]Beyond these problems of fragile inference, this approach suffers from a more general failure in that when policy is identified by its consequences there is no way to disentangle priors from reality.

[10]As discussed in Appendix A, the fact that innovations in the money stock may reflect demand as well as supply influences helps explain the "liquidity puzzle", the finding that positive innovations in the money supply are followed by increases, rather than declines, in interest rates.

cator of the stance of monetary policy. Moreover, different indicators can lead to quite different inferences and possibly inconsistent results; and using a variety of alternative measures of monetary policy cannot guarantee that some more accurate indicator has not been excluded, that the best indicator is not perhaps some combination of the various 'pure' indicators, or that the best indicator is the same for all countries or for all periods (Bernanke and Mihov (1998)). However, the use of a narrow money aggregate, as is done here, helps to mitigate these problems.

3.2 Estimation Procedure

For both the core and augmented models, the standard Choleski decomposition is used to identify impulse responses to monetary policy innovations. Formally, suppose that each VAR model is written in structural form as

$$A_0 y_t = A(L) y_t + \varepsilon_t, \tag{1}$$

where y_t is the vector of variables considered in the model, A_0 is a matrix of impact multipliers, L is the lag operator, $A(L)$ are matrix polynomials in L, and ε_t is a vector of serially uncorrelated structural disturbances with a variance-covariance matrix Ω_ε. The reduced form of (1) is given by

$$y_t = A_0^{-1} A(L) y_t + A_0^{-1} \varepsilon_t = B(L) y_t + u_t, \tag{2}$$

where u_t is a vector of reduced-form disturbances, whose variance-covariance matrix Ω_u is given by

$$\Omega_u = A_0^{-1} \Omega_\varepsilon A_0^{-1\prime}. \tag{3}$$

The moving average form of (2) is

$$y_t = C(L) u_t, \qquad C(L) = [I - B(L)]^{-1}, \tag{4}$$

where I is the identity matrix. The matrix $C(L)$ allows one to trace the path of the variables in the system as a function of past structural disturbances.

To identify the parameters in $C(L)$ requires knowledge of A_0, which is not known. As is standard in the literature, two identification restrictions are made. First, the variance-covariance matrix of the structural disturbances,

Ω_ε, is assumed to be diagonal, implying that the structural shocks are orthogonal.[11] Second, the matrix A_0 is assumed to be lower triangular. Both assumptions lead to the Choleski factorization of Ω_u. It can be shown that for this matrix there exists a unique lower triangular matrix P and a unique diagonal matrix Σ such that $\Omega_u = P\Sigma P'$. This decomposition is very similar to (3). The Choleski factorization allows us to orthogonalize the reduced-form innovations and to obtain the transformed residuals $\upsilon_t = P^{-1}\varepsilon_t$. For the impulse response analysis this implies

$$y_t = C(L)PP^{-1}u_t = G(L)\upsilon_t.$$

The analysis reported below considers the impulse response functions given by $G(L)$, with the respective shocks contained in the vector of orthogonalized disturbances, υ_t. Given that the structural disturbances are orthogonal as well, this vector coincides with the true structural disturbances if $\varepsilon_t = A_0^{-1}u_t = P^{-1}\upsilon_t$. Whereas the matrix P is unique for a given Ω_u, the variance-covariance matrix itself depends on the ordering of the variables in the system.

The assumption that A_0 is lower triangular is critical for identification . It imposes a recursive form on the contemporaneous form of the contemporaneous correlations in the system, implying that if there is a high contemporaneous correlation between two reduced-form innovations, then the complete effect is assigned to the innovation that comes first in the ordering of the VAR.[12] Here, to implement the Choleski decomposition of the covariance matrix, the disturbances in the "core" VAR model for instance are assumed to follow the causal ordering: output gap innovation→inflation innovation→exchange rate innovation→ interest rate innovation. Let μ be the nominal rate of exchange rate depreciation, i the money market interest rate, π the inflation rate, and $\ln(y/y_T)$ the output gap, with y denoting

[11] Note that this is a strong assumption. In the "core" model with four equations, for instance, it implies that the economy is driven only by four "primitive" shocks, which are orthogonal to each other. If the number of true shocks were larger, the four identified shocks would be linear combinations of the true original shocks and the assumption of orthogonality would no longer hold.

[12] Note that the identifying assumptions restrict only the contemporaneous correlation matrix, while the correlations between higher lags of the variables remain unrestricted. This means that once the disturbances are identified, the impulse response functions are a suitable instrument to investigate the dynamic structure of the system, taking into account both direct and indirect effects.

real output and y_T trend output (see Appendix B for a more complete description). The sequence is thus $\ln(y/y_T)$-π-μ-i. Under this scheme (with the policy variable ordered last), no variable other than the interest rate responds contemporaneously to the monetary policy shock. The fact that the output gap and inflation, for instance, are placed before the policy variable in the VAR captures the assumption that monetary policy shocks have no contemporaneous impact on these variables, or equivalently that the output gap and prices take at least one quarter to respond to monetary shocks. Any contemporaneous correlation between a disturbance to the policy variable and the output gap is thus taken to reflect causation from output to the policy variable, and not the other way around. Put differently, the monetary authority is assumed to look at the contemporaneous state of real activity, prices and the exchange rate before deciding on the monetary policy innovation.

Although the above ordering scheme is common in the literature on monetary policy using VARs (see, for instance, Christiano, Eichenbaum, and Evans (1996)), its generality is admittedly open to question. In most countries output and prices are not observed contemporaneously, so strictly speaking the monetary authority cannot condition its intervention on contemporaneous observations. Nonetheless, partial information on real activity and (to a greater extent) prices is often available through the quarter. The exchange rate is more problematic. As an asset price, it responds very quickly to monetary innovations; but it is also clear that in practice central banks generally take into account current information on the foreign exchange market when setting short-term interest rates. This suggests that some sensitivity analysis to at least the ordering with respect to the exchange rate might be warranted. However, experiments with several alternative orderings indicated that the results were not at all sensitive to the particular choice described above.

As indicated earlier, three alternative techniques are used to capture potential asymmetric effects of monetary policy. I use *a*) the sign of the initial output gap (positive or negative); *b*) the initial level of inflation (high or low); and *c*) the initial level of the monetary policy instrument itself (high or low). The first procedure requires to partition the sample on the basis of whether (the logarithm of) the output gap is positive or negative. Specifically, following Macklem (1995), let D be a dummy variable that takes the value 1 if the output gap is positive and 0 otherwise, and let x denote the monetary policy instrument. To account for asymmetric effects the core VAR is expanded to five variables by replacing x in the core (or symmetric) model by two measures of the monetary policy stance: $x^+ = Dx$, and $x^- = (1 - D)x$.

The ordering chosen is now $\ln(y/y_T)$-π-μ-x^+-x^-.[13] For the second approach, a similar procedure is used: the dummy D takes the value 1 if inflation is greater than its sample average plus one standard error, and zero otherwise. For the third, D takes the value 1 if the instrument is above or below its sample average value plus and minus one standard deviation, and zero otherwise. In all cases, the dummy variable is entered directly in each of the equations of the expanded VAR so as to allow the intercept to shift along with the slope coefficients. The optimal lag length chosen for the symmetric VAR is imposed in each asymmetric experiment, in order to facilitate comparisons.

4 Estimation Results

Both "core" and extended VARs were estimated using quarterly data for four middle-income developing countries: Korea, Malaysia, the Philippines, and Turkey. Estimation period is 1978-94 for the Philippines and Turkey, 1981-99 for Korea, and 1978-97 for Malaysia. In each estimated model seasonal dummies and a time trend were used as exogenous variables. Capacity output $\bar{y}$ in all cases was measured using two alternative univariate techniques: a quadratic trend (QT), and the Hodrick-Prescott (HP) filter.[14] It should be kept in mind, however, that because of the difficulties of measuring capacity output, the output gap is likely to be subject to a significant margin of error.[15] In order to determine whether the core VAR should be formulated in terms of levels or first differences, I performed standard stationary tests, whose results are reported in Appendix B. These results indicate that in almost all cases, the variables as defined here are stationary and using a vector cointegration approach is not required.[16] The optimal lag length for

[13]The ordering of the latter two variables is purely arbitrary; the results are not sensitive to the ordering shown here.

[14]See Dupasquier, Guay, and St-Amant (1999) for a comparison of alternative multivariate techniques to measure potential output.

[15]As shown by Galí (1999), in the presence of nominal rigidities supply shocks may move detrended output and the "true" output gap in opposite directions. Moreover, as noted by Galí and Gertler (1999), the output gap is not in general a good proxy for real marginal costs (equal to the ratio of the real wage rate to the marginal product of labor if the production technology is Cobb Douglas), which is a more relevant measure of real economic activity.

[16]An alternative approach would have been to specify a VAR model in which output and other variables are measured in levels despite being nonstationary. As shown by Sims,

each model was determined on the basis of the Akaike criterion and visual inspection of the impulse response functions (described below).

In the "extended" model, to assess whether the discount rate or the base money growth rate should be added to the core VAR, I performed a block exogeneity (or block causality) test by re-estimating the core VAR with each variable added one by one, to obtain the variance-covariance matrix of the residuals associated with the unrestricted model, Ω_U. With Ω_C denoting the variance-covariance matrix of the core (restricted) model, the likelihood ratio statistic, λ, is calculated as

$$(T-N)(\ln|\Omega_C| - \ln|\Omega_U|),$$

where T denotes the number of observations, $\ln|\Omega_h|$ the natural logarithm of the determinant of Ω_h, and $N = np+1$ represents the number of parameters estimated in each equation of the unrestricted system—with n the number of variables in the extended model (that is, the number of variables in the "core" model, n_c, plus one, since the test is performed for each additional variable one at a time), and p the uniform lag length. This statistic has a χ^2 distribution with degrees of freedom equal to $n_c p$ (because p lagged values are excluded from each equation). Results of applying this block exogeneity test are reported in Table 1 for each of the four countries in the sample. They indicate that the null hypothesis (exclusion of the discount rate or the growth rate of the base money stock) is rejected for each country except for Turkey, for which exclusion of the discount rate is accepted.

5 Impulse Response Analysis

The impulse response functions over 24 quarters associated with a one standard deviation shock to the innovation in each policy instrument are shown in Figures 1 to 12, for both symmetric and asymmetric cases. The solid lines in the figures represent the impulse responses themselves, whereas the dotted

Stock and Watson (1990), least-squares estimates are consistent for the levels specification (whether cointegration exists or not), whereas a differenced specification is inconsistent if some variables are cointegrated. But in the absence of cointegration, the estimated standard errors of the levels specification are not consistent, so conventional inference could potentially be misleading. Yet another alternative could be a vector error-correction specification (see for instance Clarida and Gertler (1995)).

lines are the associated 95 percent upper and lower confidence bands.[17] As noted earlier, the results are not sensitive to alternative orderings and are not in general sensitive to the way the output gap is measured. I consider in turn, impulse response functions associated with the money market rate, the discount rate, and the growth rate of the monetary base.

Based on standard analyses of the monetary transmission mechanism (see for instance Kamin and Van't dack (1998)), an increase in interest rates (either the money market rate or the discount rate) is expected in the short term to have a negative effect on output and inflation, an ambiguous effect on the money supply (depending on whether the reduction in the transactions demand for money outweighs or not the effect of a higher opportunity cost on the "speculative" demand for currency balances), and to lead to an appreciation of the nominal exchange rate (stemming from the fact that the rise in domestic interest rates leads to an increase in the demand for domestic-currency assets and an inflow of capital). Over time, however, the downward pressure in domestic prices associated with higher interest rates and the initial reduction in aggregate demand may generate a positive wealth effect, which may be large enough to stimulate domestic output, increase money demand (and thus interest rates) and spending on imports, thereby increasing the demand for foreign exchange and leading to a depreciation of the domestic currency. The effects of an expansionary monetary shock taking the form of a positive innovation in the money base growth rate depend on whether the "liquidity" effect dominates or not the "expectations" (or Fisher) effect. The liquidity effect predicts that an increase in money supply should be accompanied by a reduction in interest rates (to restore equilibrium in the money market), and thus higher output and prices as well as an exchange rate depreciation in the short term. On the contrary, the expectations effect predicts that an increase in the money supply raises inflation expectations to such an extent that interest rates actually rise, thereby lowering output, prices, and leading to a depreciation of the exchange rate.[18] Over time, as is the case with interest rate changes, wealth effects induced by changes in inflation (and possibly exchange rates) may offset short-term effects.

[17] The impulse responses and their associated confidence intervals are computed using Monte Carlo simulations employing 1,000 draws. Eviews 3.1 was used to perform all computations.

[18] Appendix A discusses some of the empirical "puzzles" that recent, VAR-based studies of monetary policy shocks have uncovered. This is helpful for understanding both the symmetric and asymmetric effects derived in this paper.

5.1 Money Market Rate Shocks

Consider first a positive innovation in the money market rate, as depicted in Figure 1. In Korea the shock has no significant effect on the rate of depreciation of the exchange rate and inflation; output falls below potential after a lag of two quarters and the output gap remains negative until the eighth quarter when the QT filter is used. But this effect is not robust; it does not hold when the HP filter is used. For Malaysia, there is a slight and short-lived appreciation of the nominal exchange rate after four quarters and no significant effect on output and inflation, regardless of the filter used for estimating trend output. For the Philippines, there is a short-lived depreciation in the third quarter (a counter-intuitive result) and no impact on output. Inflation reacts perversely; it rises beginning in the second quarter for about three quarters. The increase in inflation may be the result of the exchange rate depreciation (which increases the price of tradables) combined with some degree of persistence imparted by lagged wage indexation. A similar phenomenon occurs in Turkey; the sharp and immediate nominal depreciation induced by the interest rate shock (again, a counter-intuitive result) is accompanied by a concomitant increase in inflation. There is also a significant adverse effect on output, but it is short lived.

Consider now the asymmetric effects (Figures 2 to 4), beginning with the first method (Figure 2). For Korea, the only evidence of asymmetry is with respect to the behavior of the inflation rate, regardless of the detrending technique used. When the output gap is initially positive, a positive innovation in interest rates has a significant, downward effect on inflation after two quarters; this effect lasts for about two quarters when the HP filter is used, whereas it disappears almost immediately with the QT filter. For Malaysia, the evidence of asymmetry relates only to the response of the exchange rate, which appreciates significantly (as predicted) on impact; the appreciation persists until the fifth quarter when the HP filter is used, and until the third quarter with the QT filter. There is also a weak, perverse response in the output gap, but it is not robust across filters. For the Philippines, there are some borderline asymmetric effects in the behavior of the rate of depreciation and the cyclical component of output, but these are again not robust across filters. For Turkey, by contrast, there is clear evidence of asymmetric response in all three variables, regardless of the filter used. When the output gap is initially negative, the rate of exchange rate depreciation increases significantly and inflation rises quickly, whereas when the output gap is positive the monetary shock has a recessionary (albeit mild) effect.

Regarding the second method, there is no evidence of asymmetric effects for either Korea or Turkey (see Figure 3). For Malaysia, the results suggest an asymmetric effect on the output gap when the HP filter is used, but this result is not robust with respect to the detrending filter chosen. For the Philippines, there is significant evidence of an asymmetric effect on inflation, with both filters: when the initial value of the money market rate is small, a positive innovation in interest rates leads to an increase in inflation between the second and fifth quarters. Again, this seems to reflect a short-lived increase in the rate of depreciation of the nominal exchange rate, although, interestingly enough, there is no evidence of asymmetric effect on that variable.

Regarding the third method (Figure 4), the results indicate that for Korea a positive innovation in the money market rate has a significant asymmetric effect (which is robust across filters) on the nominal exchange rate and inflation when the inflation rate is initially high. There is, as predicted, a short-lived reduction in the depreciation rate and inflation, with the fall in the latter possibly resulting from the former. A similar movement in inflation (with no corresponding movement in the rate of depreciation) is observed for the Philippines. For Malaysia, there is no evidence of asymmetry at all. For Turkey, by contrast, asymmetric behavior is discernible for all variables. When inflation is initially how, a restrictive monetary policy leads to a sharp and rapid increase (instead of a fall) in the rate of depreciation. There is also a significant fall in the output gap (after 4 or 5 quarters) and an increase in inflation. In addition, for Turkey, when the inflation rate is initially high, a positive innovation in the money market rate generates no response from the exchange rate although inflation falls slightly (but significantly) on impact.

5.2 Discount Rate Shocks

The impulse response functions due to a one standard deviation shock to the innovation in the money market rate are shown in Figure 5 for the symmetric core model, and Figures 6, 7 and 8 for the asymmetric shocks in both the core and augmented models.

Consider first the symmetric shocks (Figure 5). For Korea, the inflation rate reacts perversely to an increase the discount rate, with no significant effect on the other variables. In Malaysia, the money market rate rises immediately (as expected) and inflation drops in the second quarter (also as expected); there are no significant effects on output and the exchange rate.

For the Philippines, the sole effect of the shock is a slight reduction in the rate of depreciation on impact, whereas for Turkey there are no significant effects on any of the variables. The fact that the discount rate in the Philippines and Turkey has no impact on the money market rate may indicate that for these countries, and given the sample considered, the discount rate was not used actively as an instrument of monetary policy.

Consider now the first approach to measuring asymmetric shocks (Figure 6). For Korea, there is no evidence at all of asymmetry; the shock appears to have no significant effects at all. For Malaysia, there is clear evidence of asymmetry: regardless of whether the HP or QT filter is used, the money market rate increases, and the inflation rate falls, when the output gap is initially negative, whereas there are no perceptible effects when the economy is initially in a downswing. The effect on the nominal exchange rate, by contrast, is not robust across filters. For the Philippines, there is some evidence of asymmetry in the behavior of the money market rate, but again, it is not robust across filters. For Turkey, the same lack of robustness characterizes the response of the money market rate and the output gap.

Regarding the second approach to measuring asymmetric effects (Figure 7), there is again no evidence that the innovation in the discount rate has any effect on the variables in the system in Korea and Turkey. For Malaysia, however, an asymmetric response appears to be discernible again for the money market rate (which rises immediately) and inflation (which falls immediately also). For the Philippines, there is also now evidence of a significant reduction in the rate of depreciation of the nominal exchange rate on impact and of a perverse and somewhat persistent fall in the money market rate after 4 or five quarters. Consider, finally, the asymmetric approach based on initial values of the inflation rate (Figure 8). In the case of Korea and Turkey, there is again no evidence of any effect of the discount rate innovation on the variables included in the system. In Malaysia, when the inflation rate is initially low, a monetary contraction elicits an asymmetric response of inflation on impact, with the rate of growth of prices falling significantly. The impact of the shock on the money market rate is also highly asymmetric: whereas the response of the money market rate is positive and borderline significant when the inflation rate is initially small, it reacts perversely (and significantly) when inflation is initially high. This pattern is difficult to rationalize on the basis of the theories reviewed earlier. For the Philippines, the positive innovation in the discount rate also leads to a perverse reduction in the money market rate when inflation is initially high (and no effect on that variable when inflation is initially low). In addition, inflation also responds asymmetrically, falling significantly in response to the contractionary monetary shock when inflation is initially high but showing no discernible effect when inflation is initially low.

5.3 Money Growth Rate Innovations

The impulse response functions associated with a one standard deviation shock to the innovation in the growth rate of the money base are shown in Figures 9 (for a symmetric shock using the core model), and 10, 11, and 12 (for asymmetric shocks using both the core and augmented models). Consider first the symmetric shock (Figure 9), keeping in mind that now the positive innovation is an *expansionary* policy. In Korea, the shock has a significant effect only on inflation (after 2 or 3 quarters) and in the direction expected. In Malaysia, there is an initial reduction in the rate of nominal depreciation, despite the fact that there is no significant effect on domestic interest rates, and an immediate (and short-lived) rise in inflation. In the Philippines, the rate of depreciation of the nominal exchange rate falls on impact (despite a slight and transient increase in domestic interest rates in the third and fourth quarters after the shock) and inflation rises slightly and briefly after three quarters. Finally, in Turkey, there is evidence of a small and short-lived positive output effect but no impact on the other variables.

Consider now the first approach to measuring asymmetric shocks (Figure 10). In the case of Korea, there is significant evidence of an asymmetric effect on inflation, regardless of the filter used: inflation tends to increase (after 2 or 3 quarters) in response to a positive shock to the money growth rate when the output gap is initially negative. A similar asymmetric effect can be detected for Malaysia. For the Philippines, there is evidence of an asymmetric movement in the nominal rate of exchange rate depreciation; when the output gap is positive, the rate of depreciation rises at first (despite the increase in domestic interest rates) and falls subsequently. There is also evidence of a significant asymmetric movement in the behavior of inflation: when the output gap is initially positive, a positive money growth rate shock raises temporarily inflation (after 3 or 4 quarters), whereas there is no discernible effect when the output gap is negative. This result suggests that monetary policy may not be effective in a recession–perhaps as a result of abrupt changes in confidence. For Turkey, the only significant evidence of asymmetry is with respect to the output gap; when initially output is below its trend level, an expansionary monetary shock has a positive and immediate effect on economic activity that lasts for about 3 quarters.

Regarding the second approach to asymmetry, the impulse response functions for Korea suggest some evidence of asymmetry regarding the inflation rate—a positive effect when the initial value of the money growth rate is small (Figure 11). This is similar to the result obtained in previous experiments. In the case of Malaysia, when the money growth rate is initially high, and regardless of the filter used, there is evidence of asymmetry in the behavior of the rate of nominal depreciation—the money market rate falls (which is consistent with a liquidity effect), the depreciation rate falls (which is consistent with the fall in interest rates), and inflation increases. For the Philippines, asymmetric patterns characterize the behavior of market interest rates and, to a greater extent, the depreciation rate and inflation: when the money growth rate is initially high, a positive money shock raises interest rates, the depreciation rate and inflation (after four or five quarters) for about 2 or 3 quarters; but when the money growth rate is initially small, the same shock has no effect on the money market rate whereas it lowers the depreciation rate and inflation in the fifth quarter for about 2 or 3 quarters. Finally, for Turkey, asymmetry appears to be present only in the behavior of the output gap: when the money growth rate is initially small, a positive money shock raises output above its trend level immediately, with an effect lasting for about 2 quarters; by contrast, when the money growth rate is initially high, the same shock has no effect on activity. Again, these effects are difficult to rationalize based on the theories highlighted above.

Consider, finally, the third approach to measuring asymmetric effects (Figure 12). In the case of Korea, the results suggest that a positive innovation in the base money growth rate has a perverse, asymmetric positive effect on the money market rate, which tends to increase rather than fall (an example of the "liquidity puzzle" discussed in Appendix A). Effects on other variables (including inflation) are not significant. In the case of Malaysia, asymmetric effects are also discernible: when inflation is initially low, the rate of exchange rate depreciation falls on impact, despite the fact that money market rates show no apparent movement. Inflation rises as a result of the monetary expansion when inflation is initially low, but shows no significant response when it is initially high. In the case of the Philippines, the money market rate responds markedly differently when inflation is high compared to when it is low: in the first case, it falls on impact, whereas in the second it rises. This behavior is puzzling because one would expect exactly the opposite response on the basis of liquidity and expectations effects. When inflation is initially low, the liquidity effect of monetary expansion should dominate (and thus interest rates should fall), whereas when inflation is initially high, the expectations effect might dominate (and thus interest rates should rise). For Turkey, finally, there are also signs of asymmetric responses in the behavior of output and inflation. When inflation is initially low, a monetary expansion has a short-lived expansionary effect on output and none when it is already high. Surprisingly enough, a rise in the rate of growth of base money lowers inflation significantly on impact when inflation is already high.

6 Summary and Conclusions

The purpose of this paper has been to examine, using small-scale vector autoregression models, the extent to which monetary policy shocks have asymmetric effects on output fluctuations, inflation and the rate of exchange rate depreciation. The first part reviewed various explanations of the sources of asymmetric effects of monetary policy, namely, confidence factors, nominal wage stickiness, capacity constraints, price rigidity induced by menu costs, and credit constraints. The "confidence view" predicts that a fall in interest rates may lead to a proportionately smaller increase in output in a recession than an increase in interest rates of the same amount would reduce output in an expansion. Menu costs model along the lines of Ball and Mankiw (1994) argue that because prices are sticky downward, a negative monetary shock reduces output substantially. By contrast, a positive monetary shock has a smaller absolute effect on output, because prices adjust more quickly. This asymmetric response does not exist at zero inflation and becomes more pronounced at higher rates of inflation. In addition, the degree of asymmetry is positively related to the size of the shock. The available evidence (which pertains mostly to industrial countries) on asymmetric effects of monetary policy shocks was then reviewed and it was noted that three approaches have been followed in testing for asymmetric effects: tests based on the *sign* of monetary policy shocks (defined either through residuals from an estimated policy rule, or as reduced-form innovations in a VAR), the *size* of monetary policy shocks, and the *sign* or *magnitude* of another variable such as the phase of the business cycle.

The third part of the paper proposed three approaches to testing for the presence of asymmetric effects in the transmission process of an expansionary monetary policy shock: the first relies on the sign of the output gap, the second on the initial level of the monetary policy instrument itself, and the third on the level of inflation. It also suggested three alternative ways to measure monetary policy shocks (innovations in the money market rate, the discount rate, and the monetary base), for two reasons. First, using the money market interest rate only as the monetary policy indicator may not be appropriate if innovations in the short-term market rate may mix together shifts in the supply of liquidity in the financial system that are initiated by the central bank with shifts in the private sector demand for loans and the supply of savings. Second, in the group of countries considered in this study, the exact nature of the policy instrument used during the sample period is difficult to identify and may well have changed at times. The fourth and fifth parts presented estimation results and impulse response functions, using quarterly data, for four developing countries: Korea, Malaysia, the Philippines, and Turkey. The identification assumption used was that the central bank can respond to contemporaneous variables in the economy when setting interest rates, but that the policy rate does not have a contemporaneous impact on the economy. The results, which appeared to be fairly insensitive to the particular ordering chosen, indicated that monetary policy shocks (whatever the measure used) have significant asymmetric effects on output, inflation and the exchange rate.

The empirical analysis presented in this paper can be extended in a number of ways. First, the results produced several "puzzling" responses, which were inconsistent either with existing explanations of asymmetric effects or simply standard macroeconomic theory. Explaining these puzzles, either along the lines of existing attempts (as discussed in Appendix A), or by identifying tranmission channels that are specific to the countries considered, is an important agenda for research. Second, it would be useful to have a systematic method of comparing (or choosing among) alternative possible indicators of monetary policy, because inference depends on which one is chosen. One possibility is to follow the approach developed by Bernanke and Mihov (1998) for the United States; they develop a "semi-structural" VAR-based methodology in which the indicator of the monetary policy stance is not assumed but derived from an estimated model of the central bank's operating procedures. An alternative would be to use a full structural VAR, as for instance in Leeper, Sims and Zha (1996) and Kim and Roubini (2000). This would allow also to discriminate among alternative sources of asymmetric effects—an issue that the approach used in this paper is not capable of addressing. A third alternative would be to develop a complete structural model to study the monetary policy transmission process and its asymmetric effects. As argued by McCallum (1999), more emphasis should be given to the systematic component of monetary policy behavior and correspondingly less to random shocks because shocks account for a very small fraction of policy-instrument variability. And if VAR techniques do not give rise to behavioral relationships that can plausibly be regarded as policy invariant, analysis of the effects of the systematic policy changes requires structural modelling.[19]

[19]See, however, Bernanke, Gertler, and Watson (1997) for a VAR-based method for estimating the effects of systematic or endogenous policy changes.

Appendix A
VAR-Based Empirical Puzzles

The recent literature on monetary policy shocks based on VARs for industrial countries has uncovered various "puzzles" that are important to keep in mind for the results discussed in this paper. Specifically, VAR studies have been subject to three recurring puzzles:

- The first is the *liquidity puzzle*. When monetary policy shocks are identified as innovations in monetary aggregates, immediately following an expansionary monetary policy shock, nominal interest rates in some empirical studies tend to increase rather than decrease, as predicted by the liquidity effect.[20]

- The second is the *price puzzle*. When monetary policy shocks are identified as innovations in interest rates, following an unanticipated monetary expansion (a fall in interest rates), the price level initially decreases in some studies, instead of increasing as predicted by conventional economy analysis (see Christiano, Eichenbaum, and Evans (1996), and Clarida and Gertler (1996)). Sims (1992) obtains a similar result: an increase in the money supply is associated with a strong and persistent drop in the price level, exactly the opposite of what would be expected to happen in response to an expansionary monetary policy.

- The third is the *exchange rate puzzle*. A positive innovation in domestic interest rates is often associated with a *depreciation* on impact of the nominal exchange rate, instead of an appreciation induced by capital inflows (see Kim and Roubini (2000)).

There have been several attempts to explain these puzzles. Some have suggested that innovations in monetary aggregates may not correctly represent changes in monetary policy in the presence of money demand shocks—a possibility that can be partially addressed by using (as is done in this paper) a narrow monetary aggregate as a better indicator of the stance of monetary

[20]Using short-term interest rates as the monetary policy instrument, however, several VAR studies find that a positive interest rate innovation leads to an initial fall in the money stock, consistent with the liquidity effect (Sims (1992), Gerlach and Smets (1994)) and Leeper, Sims and Zha (1996)).

policy.[21] Sims (1992) suggested that the price puzzle might be due to the fact that interest rate innovations partly reflect inflationary pressures that lead to price increases; this could be the case if, as in many developing countries, firms borrow to finance short-term working capital needs prior to the sale of output and the interest rate becomes part of the marginal cost of production. He also argued that this explanation of the price puzzle may also explain the exchange rate puzzle. He was able to reverse the price puzzle by including exchange rates and commodity prices in the VAR that he specified.

To explain the price puzzle, Leeper, Sims and Zha (1996) proposed a structural VAR approach with contemporaneous restrictions that includes variables proxying for expected inflation. Their methodology allowed them to model structural contemporaneous restrictions across different equations instead of using a recursive structure. It also allowed them to distinguish between money supply and money demand shocks, and therefore to address the liquidity puzzle as well. The results are consistent with the expected effects of a monetary contraction: an increase in interest rates, a reduction in the money supply, a transitory fall in output (or no real effects) and a persistent reduction in the price level. Similar results are obtained by Kim (1999) for the major industrial countries. Finally, Kim and Roubini (2000), extending the methodology developed by Leeper, Sims and Zha (1996) to an open economy, showed that it can explain all three puzzles associated with monetary policy in the group of large industrial countries.

[21] More fundamentally, Beaudry and Saito (1998) suggested that these puzzles appear to depend critically on the restrictions used to identify monetary policy shocks.

Appendix B
Data Sources and Unit Root Tests

The data used in this study are at a quarterly frequency and cover the period 1978:1 to 1994:4 for the Philippines and Turkey, 1981:1 to 1999:4 for Korea, and 1978:1to 1997:2 for Malaysia. Variables are measured as follows (all data are from the International Monetary Fund *International Financial Statistics*, unless otherwise indicated).

π is the rate of inflation (based on the consumer price index)

μ is the rate of depreciation of the nominal effective exchange rate.

i is the annualized money market interest rate.

i_d is the discount rate.

m is the rate of growth of the monetary base.

$\ln(y/y_T)$ is the cyclical component of output, with y denoting the industrial production index, obtained from Agénor, McDermott and Prasad (2000), and y_T is trend output, estimated with either the HP filter (with a standard smoothing parameter $\lambda = 1,600$) or a quadratic trend.

Inflation, the rate of exchange rate depreciation, and the money growth rate are measured on a quarter-to-quarter basis. Unit root rests (Augmented Dickey-Fuller tests and Phillips-Perron tests) are reported in Table A1. They indicate that all the variables defined above and used in the VARs discussed in the text are stationary, except for the discount rate in Korea, Malaysia, and Turkey, and the money market rate in the Philippines. Nevertheless, given the low power of these tests in small samples, impulse response functions based on the extended VARs are reported uniformly for all countries.

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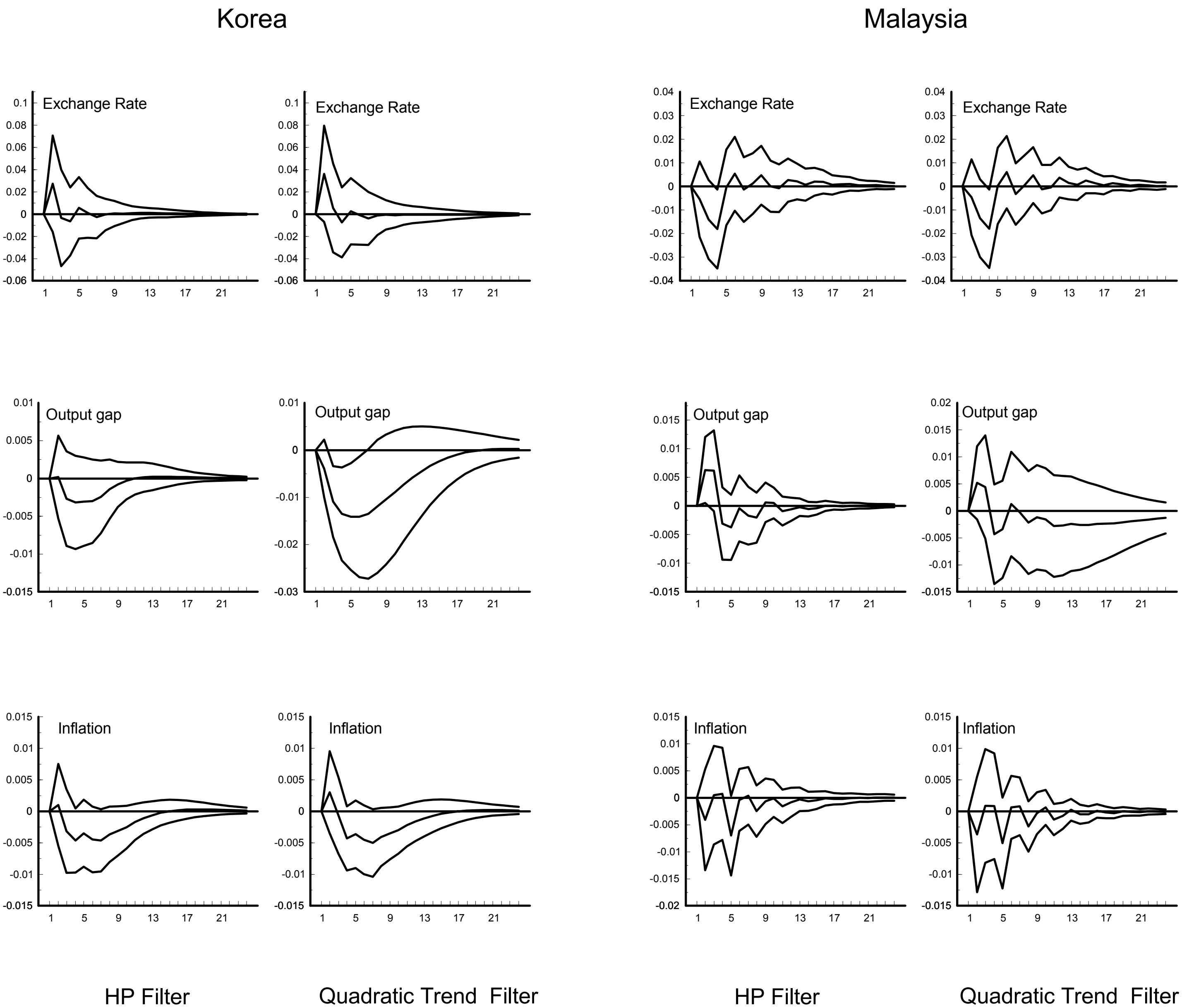
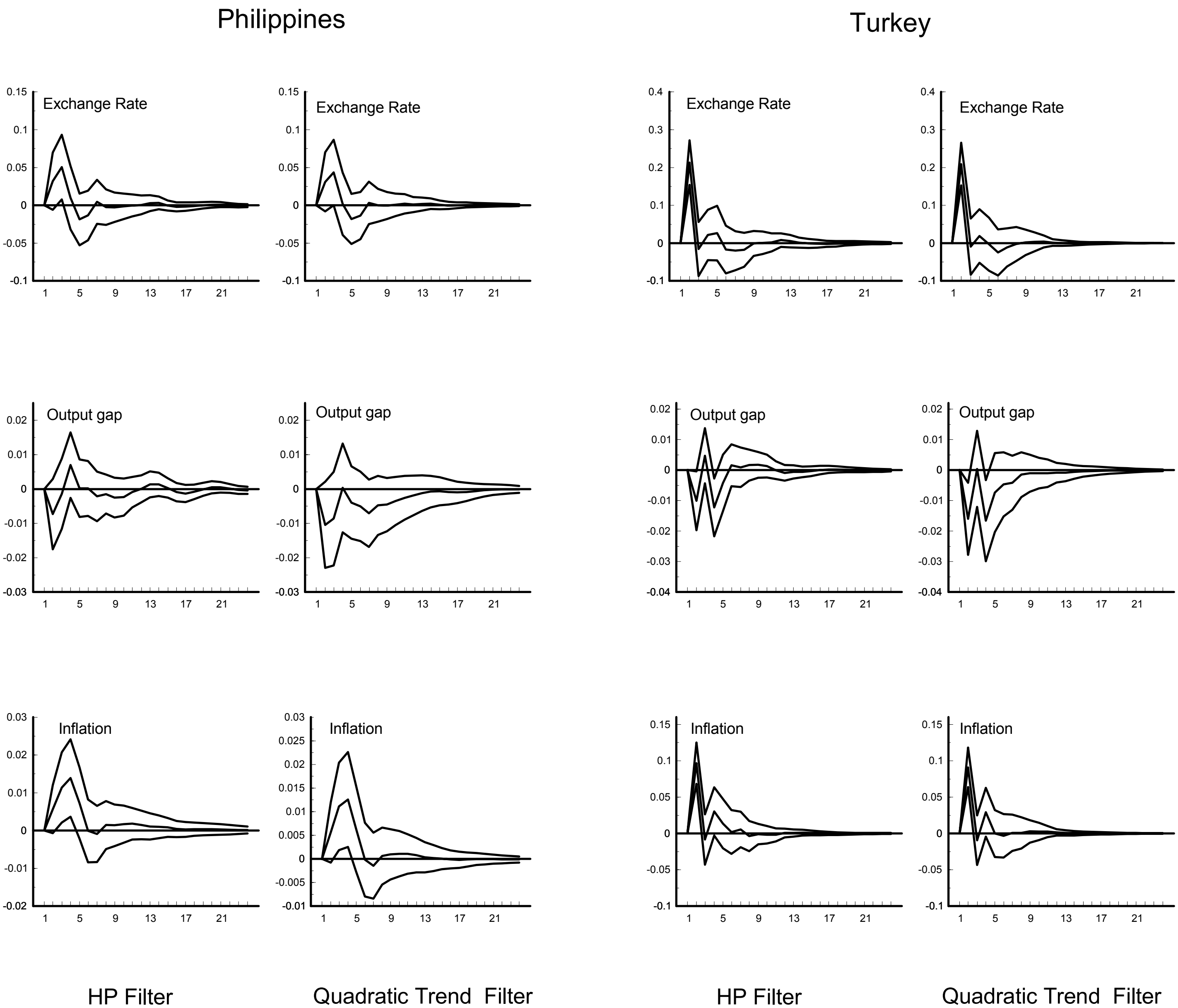
Figure 1
Symmetric Shocks:
Response to One Standard Deviation Innovations in the Money Market Rate 1/



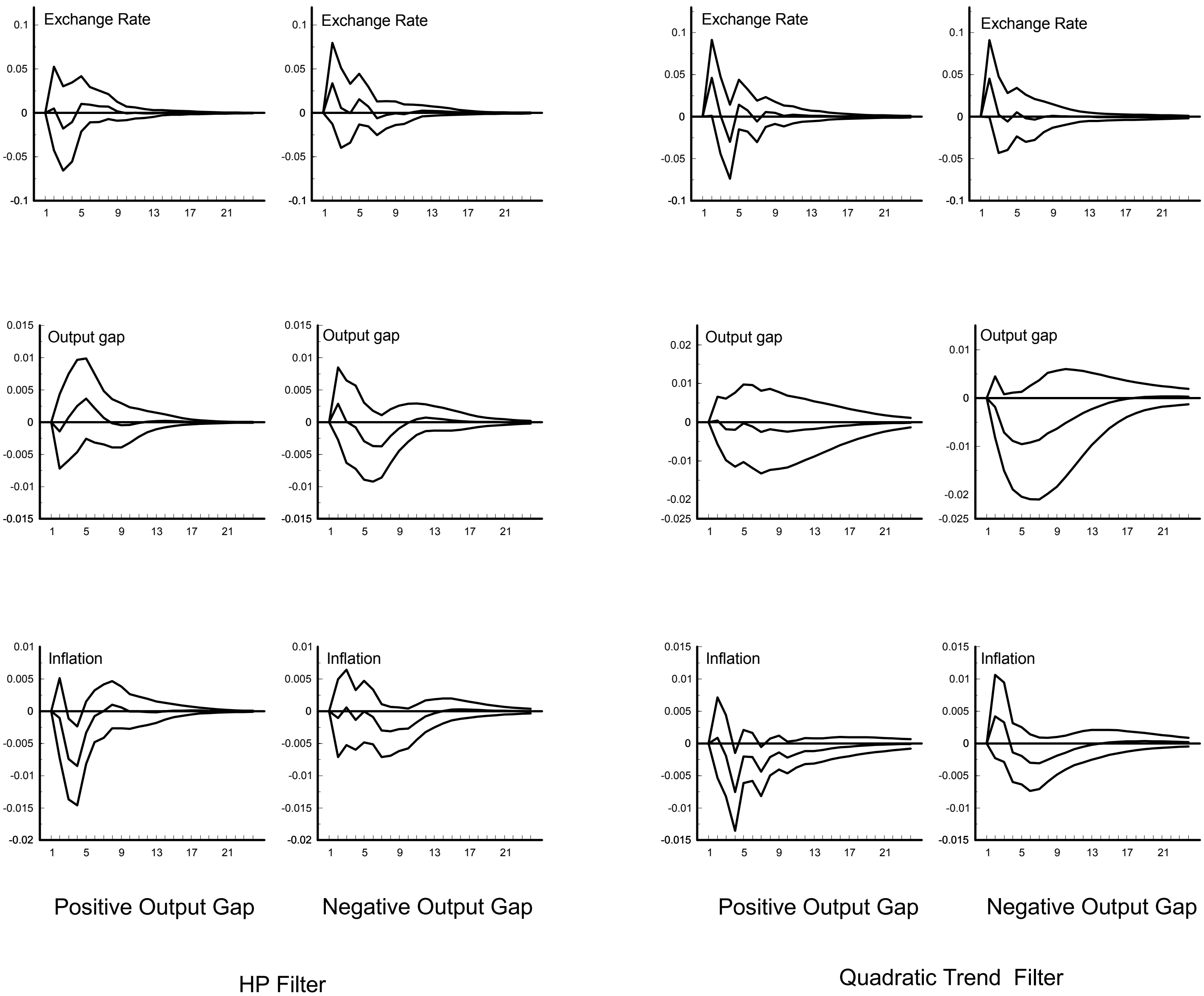
1/ Dashed lines refer to 2 standard-error bands.

Figure 1 (concluded)
Symmetric Shocks:
Response to One Standard Deviation Innovations in the Money Market Rate 1/



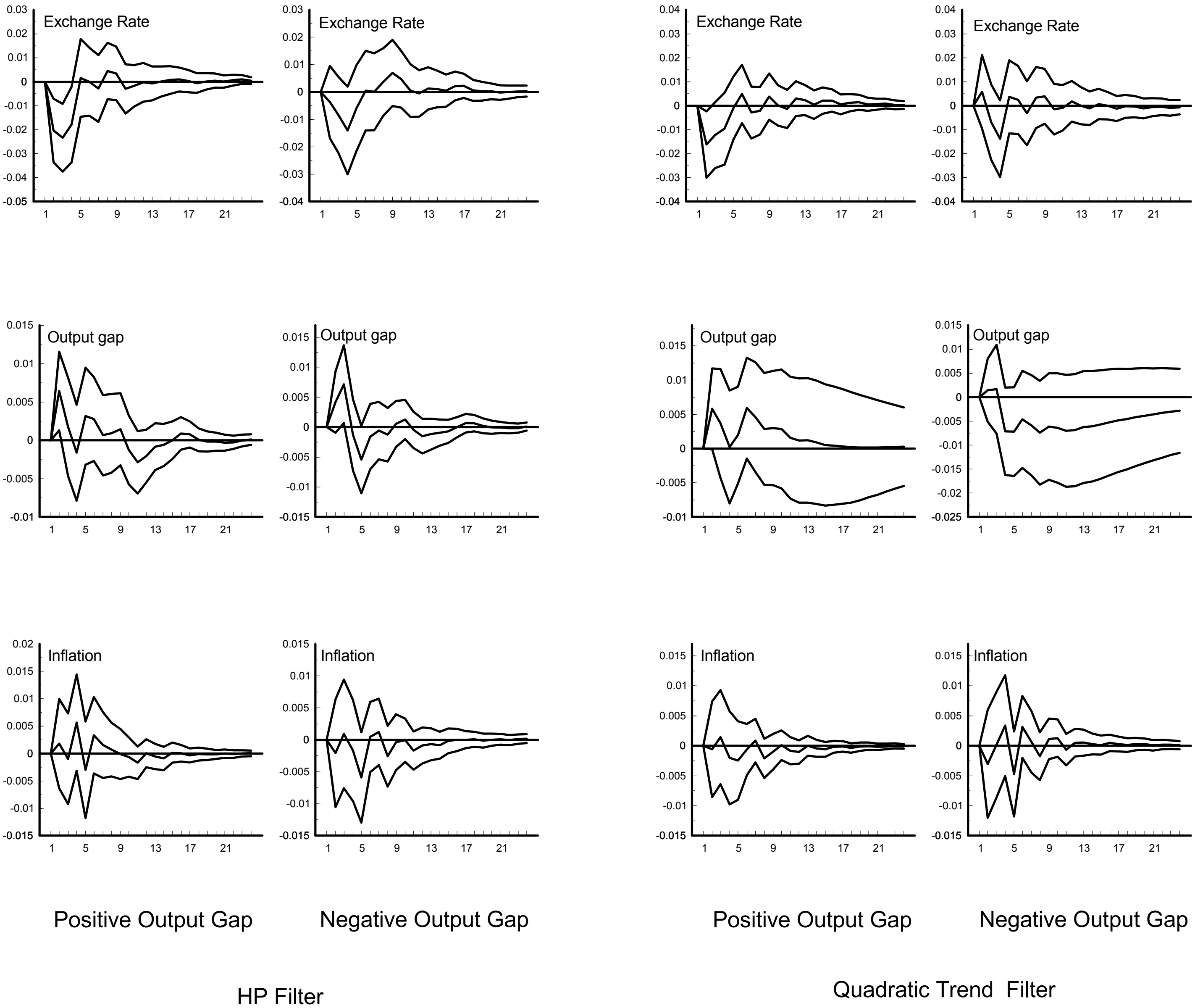
1/ Dashed lines refer to 2 standard-error bands.

Figure 2
Asymmetric Shocks (Positive and Negative Output Gaps)
Korea: Response to One Standard Deviation Innovations in the Money Market Rate 1/



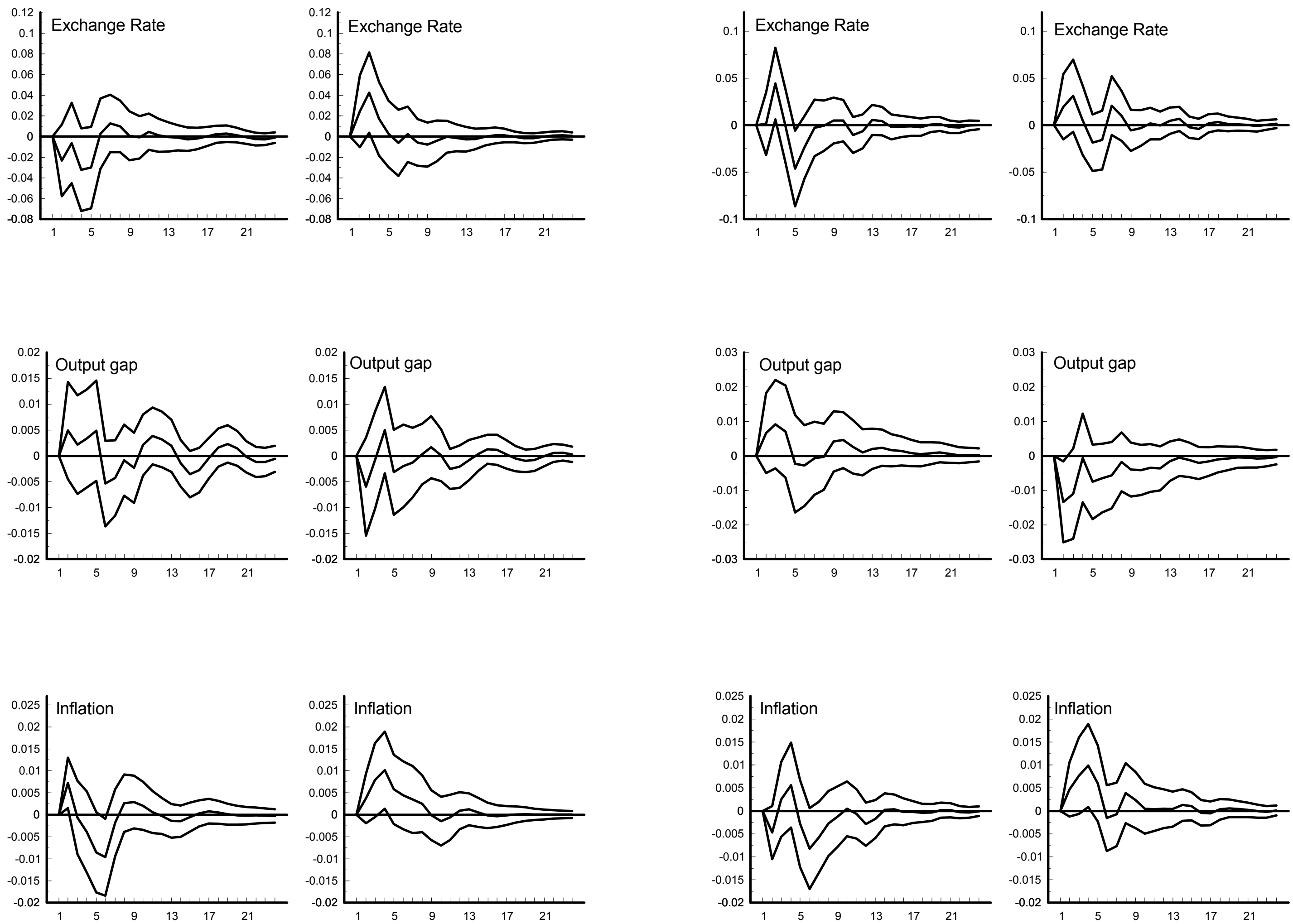
1/ Dashed lines refer to 2 standard-error bands.

Figure 2 (continued)
Asymmetric Shocks (Positive and Negative Output Gaps)
Malaysia: Response to One Standard Deviation Innovations in the Money Market Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 2 (continued)
Asymmetric Shocks (Positive and Negative Output Gaps)
Philippines: Response to One Standard Deviation Innovations in the Money Market Rate 1/

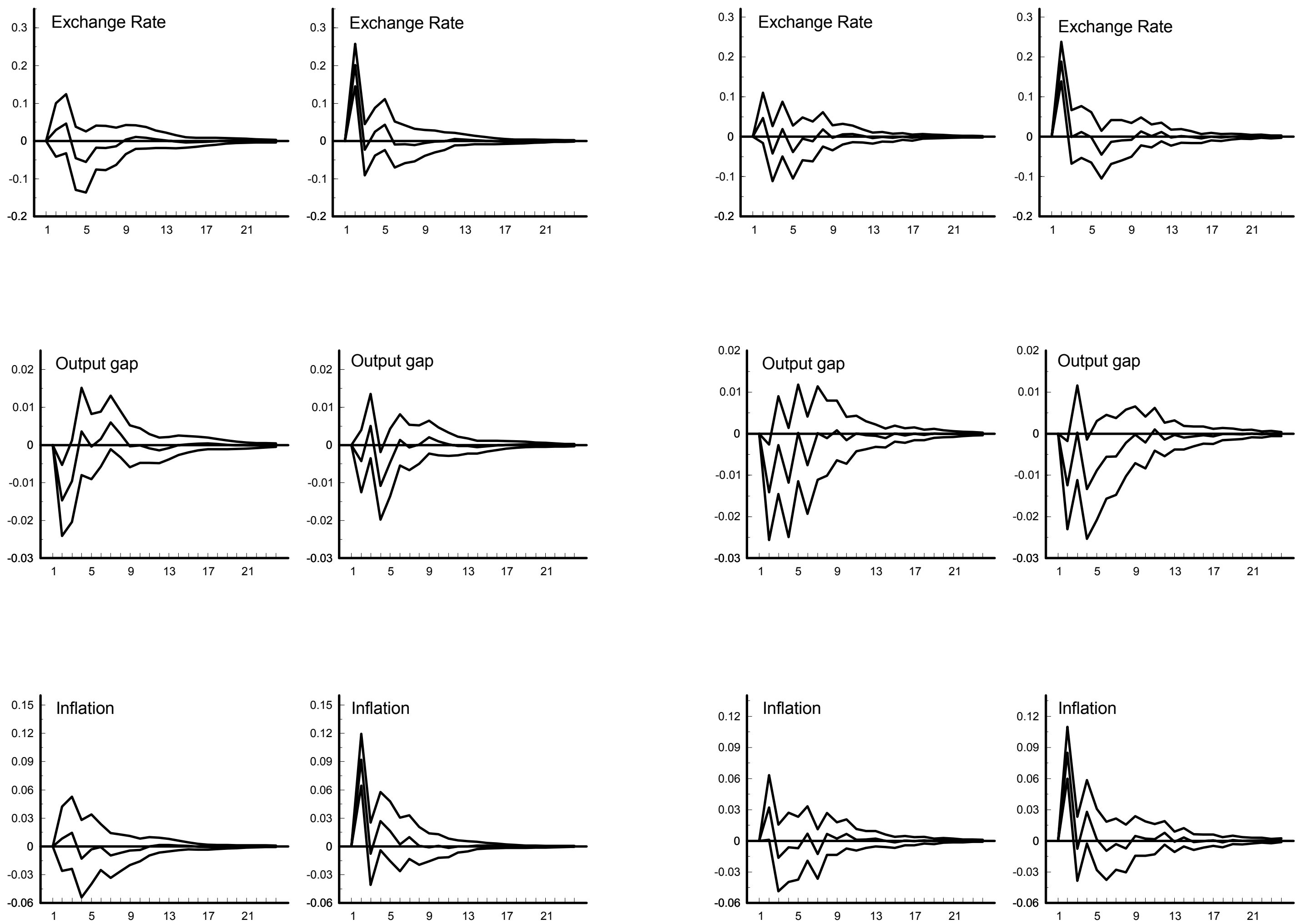


Positive Output Gap   Negative Output Gap   Positive Output Gap   Negative Output Gap

HP Filter   Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 2 (concluded)
Asymmetric Shocks (Positive and Negative Output Gaps)
Turkey: Response to One Standard Deviation Innovations in the Money Market Rate 1/

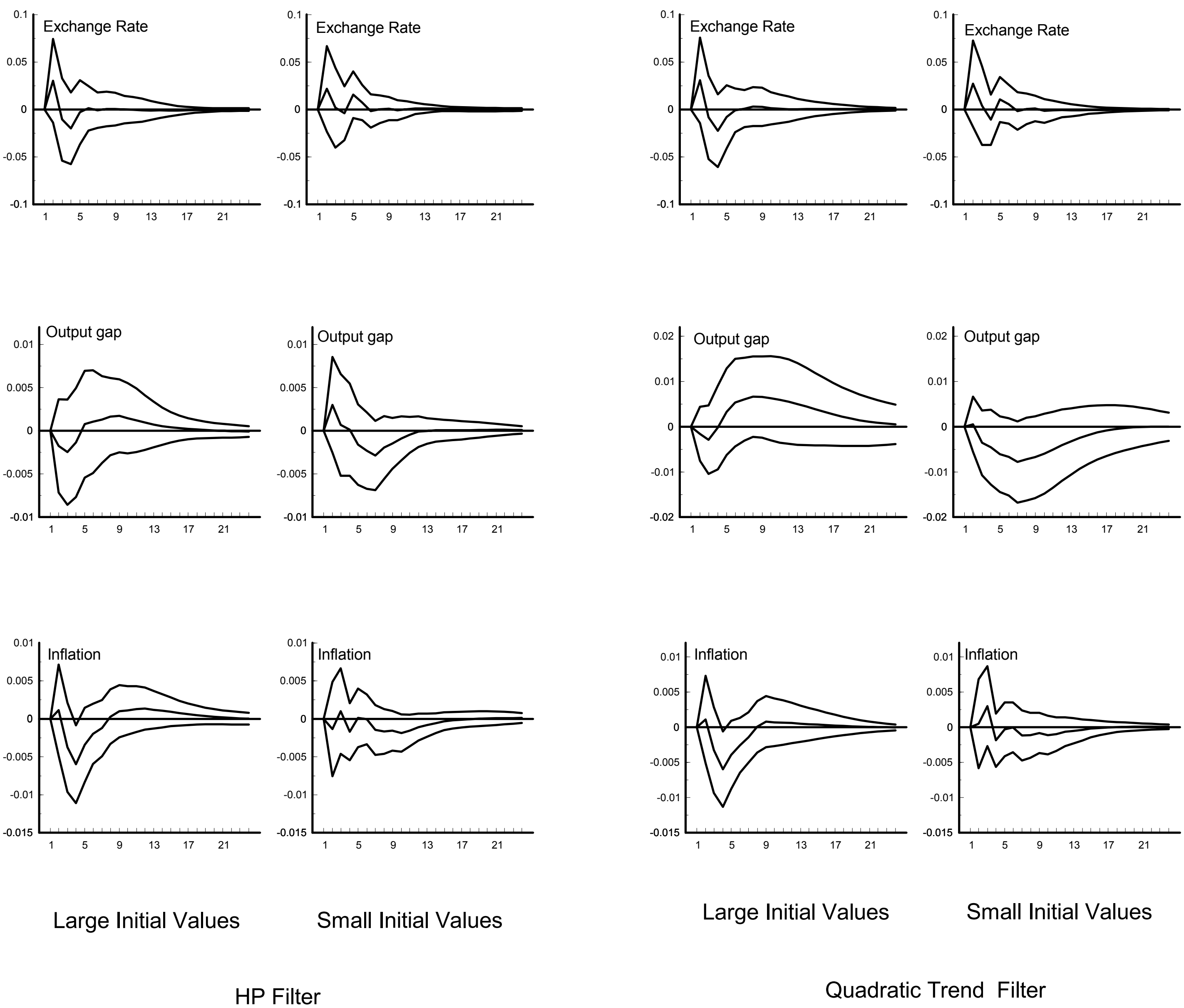


Positive Output Gap   Negative Output Gap   Positive Output Gap   Negative Output Gap

HP Filter   Quadratic Trend Filter

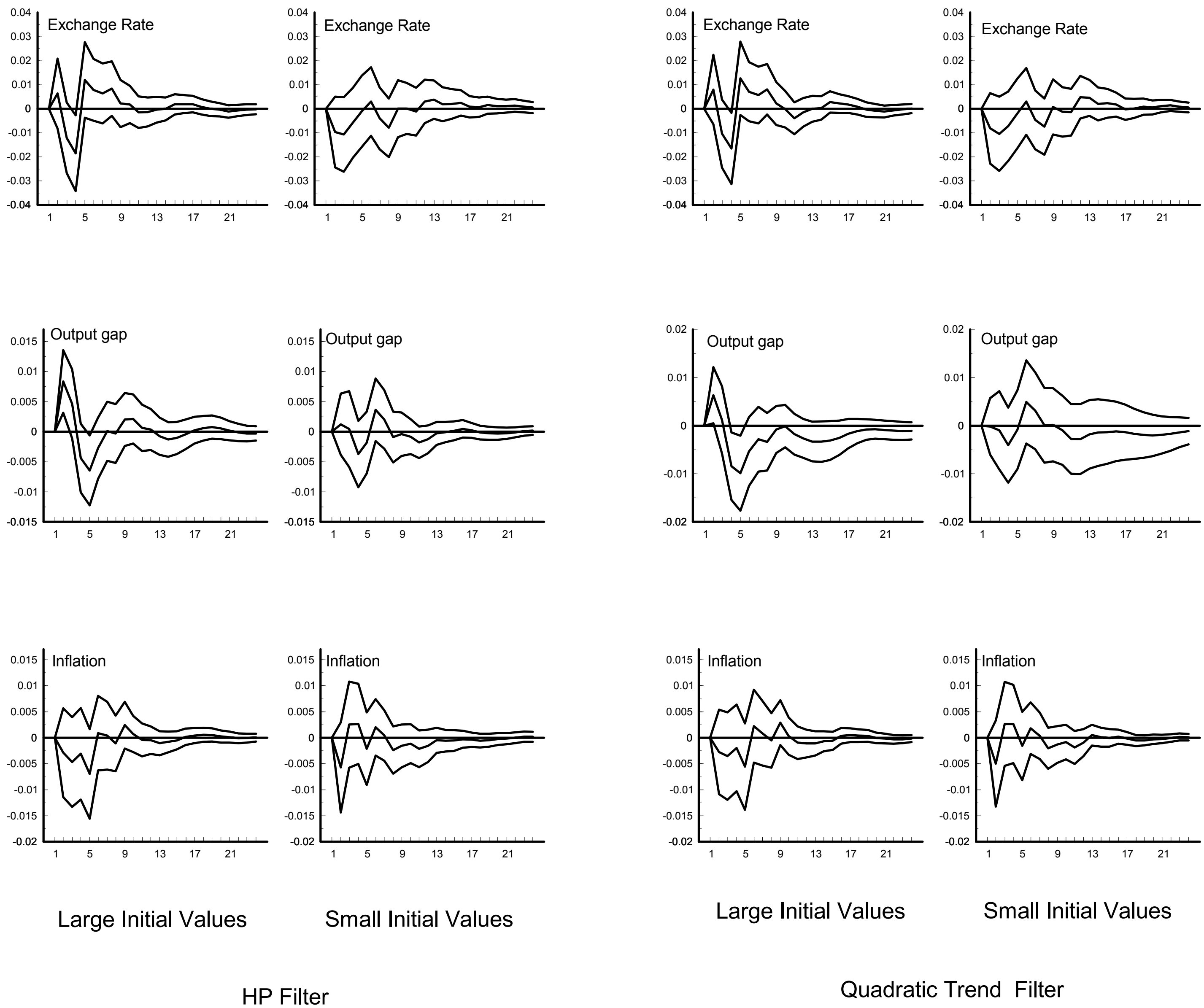
1/ Dashed lines refer to 2 standard-error bands.

Figure 3
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Korea: Response to One Standard Deviation Innovations in the Money Market Rate 1/



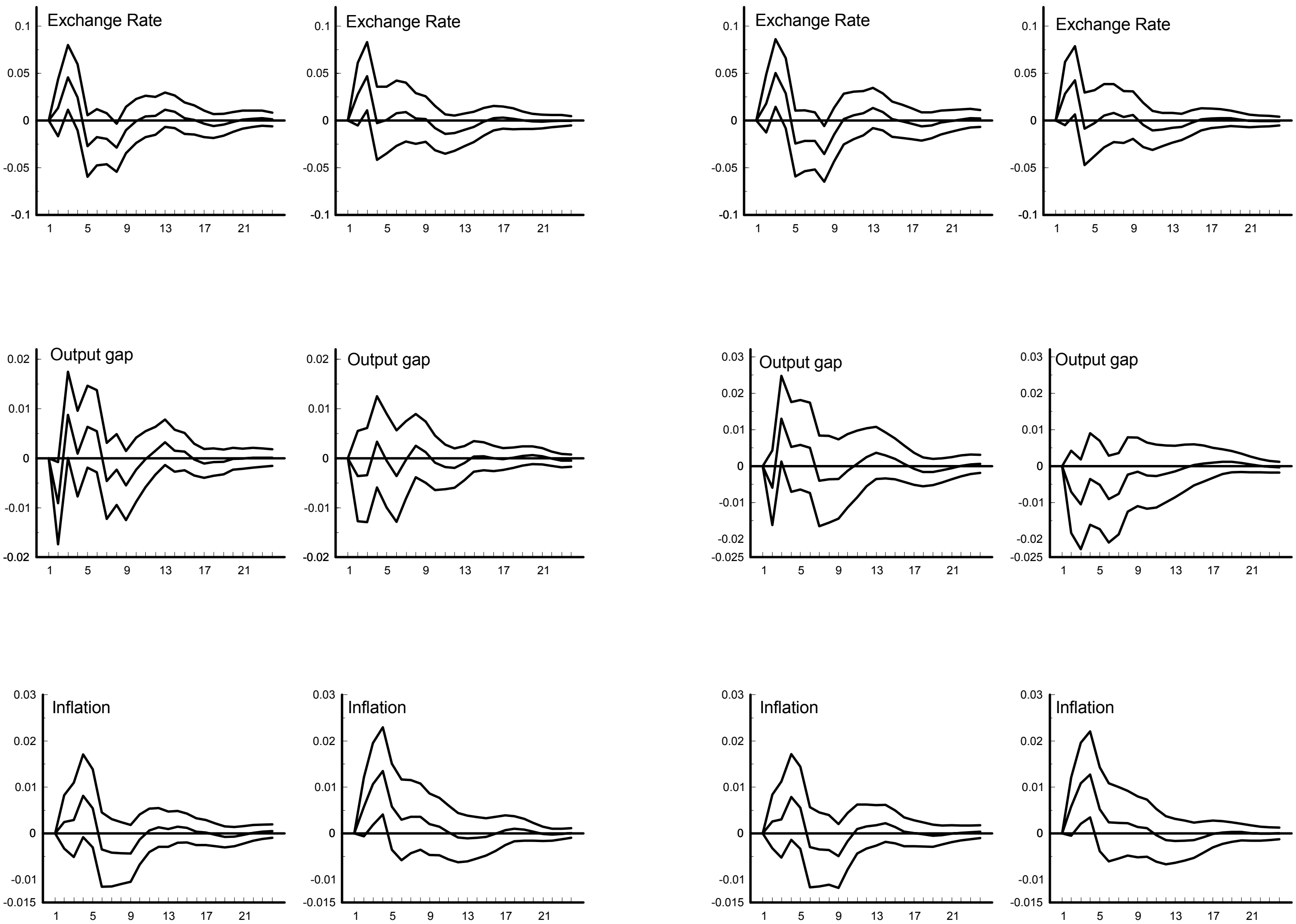
1/ Dashed lines refer to 2 standard-error bands.

Figure 3 (continued)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Malaysia: Response to One Standard Deviation Innovations in the Money Market Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 3 (continued)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Philippines: Response to One Standard Deviation Innovations in the Money Market Rate 1/

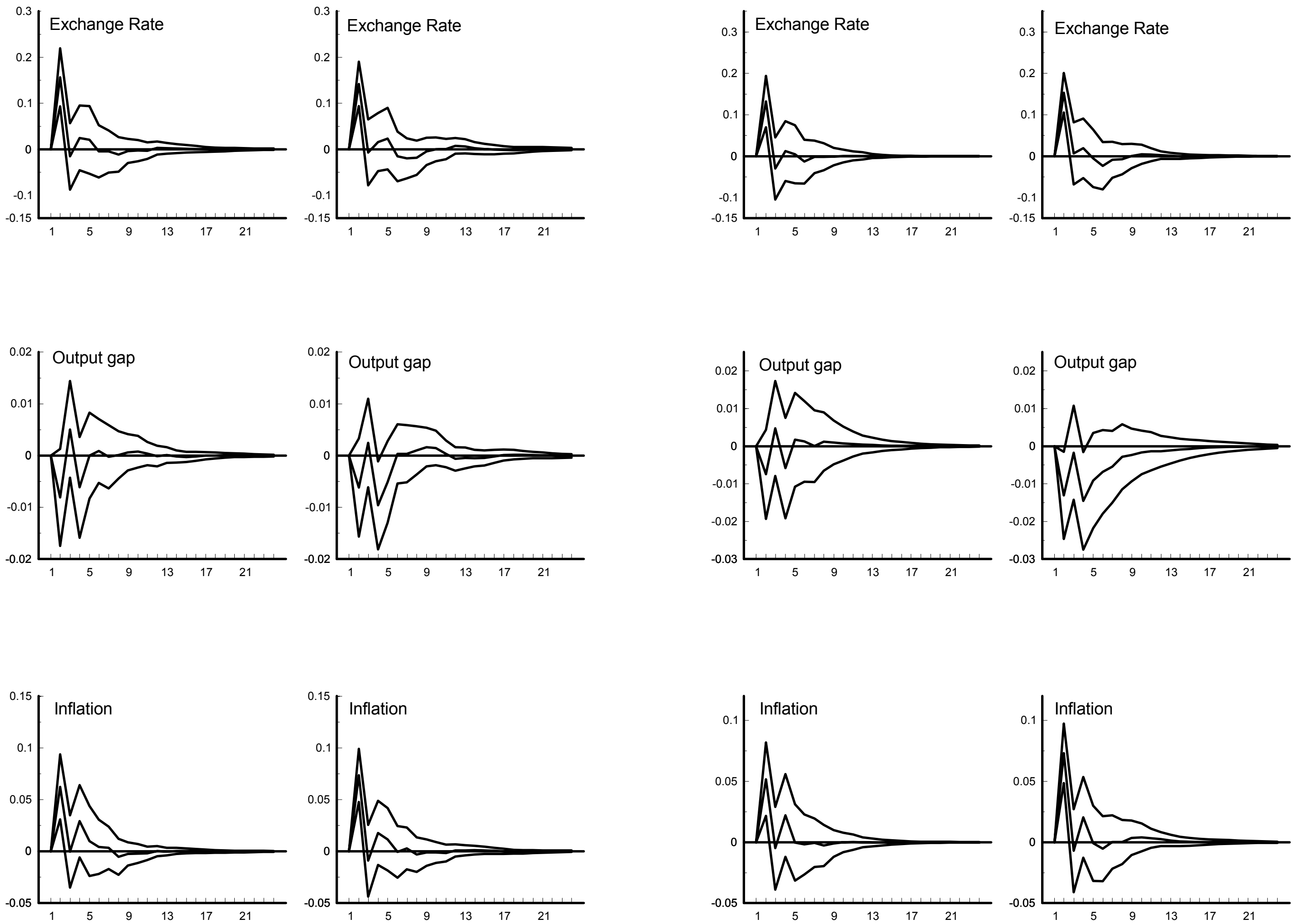


Large Initial Values   Small Initial Values   Large Initial Values   Small Initial Values

HP Filter   Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 3 (concluded)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Turkey: Response to One Standard Deviation Innovations in the Money Market Rate 1/



Large Initial Values Small Initial Values

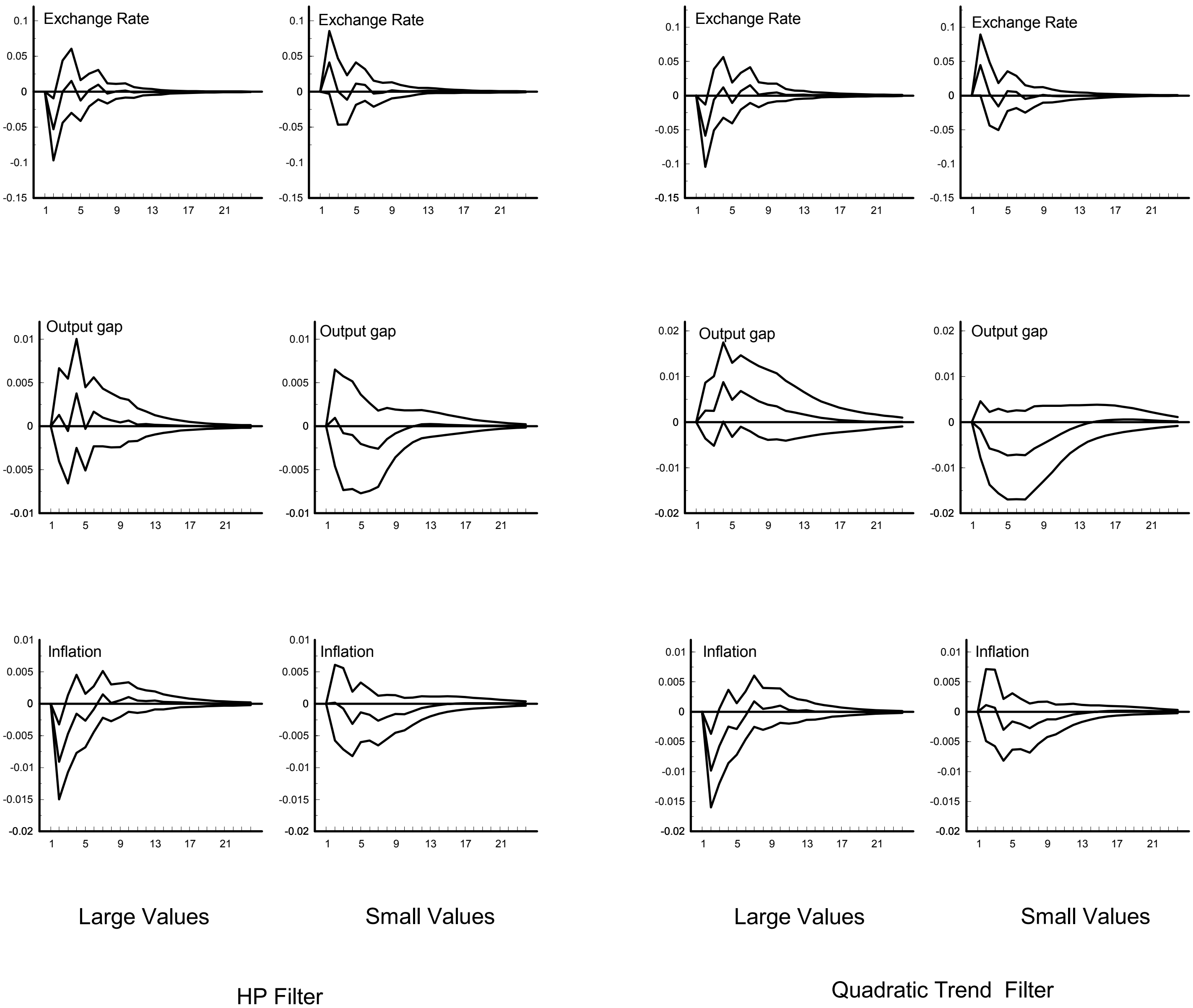
HP Filter

Large Initial Values Small Initial Values

Quadratic Trend Filter

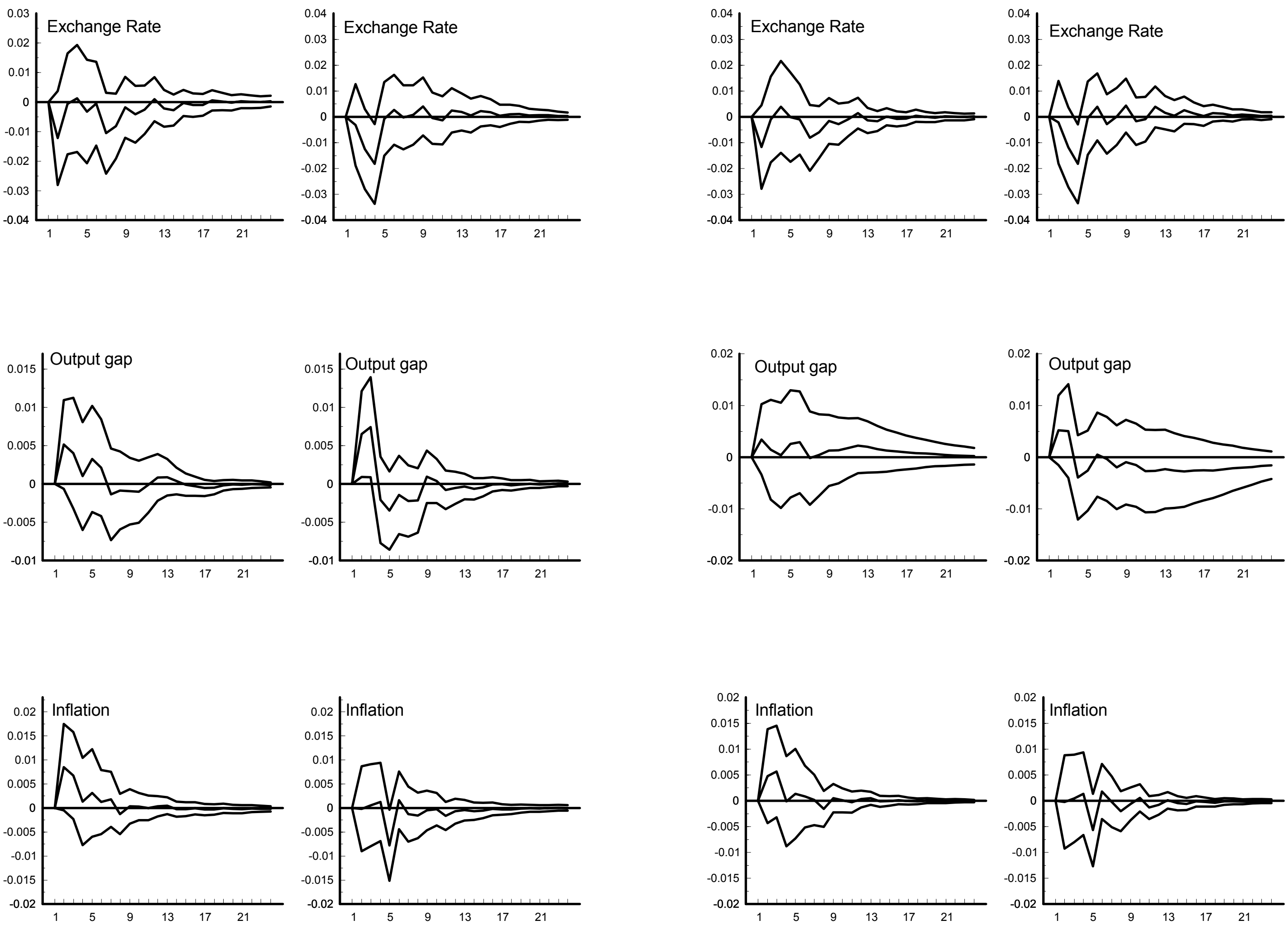
1/ Dashed lines refer to 2 standard-error bands.

Figure 4
Asymmetric Shocks (Lowl and High Values of Inflation Rate)
Korea: Response to One Standard Deviation Innovations in the Money Market Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 4 (continued)
Asymmetric Shocks (Low and High Values of Inflation Rate)
Malaysia: Response to One Standard Deviation Innovations in the Money Market Rate 1/

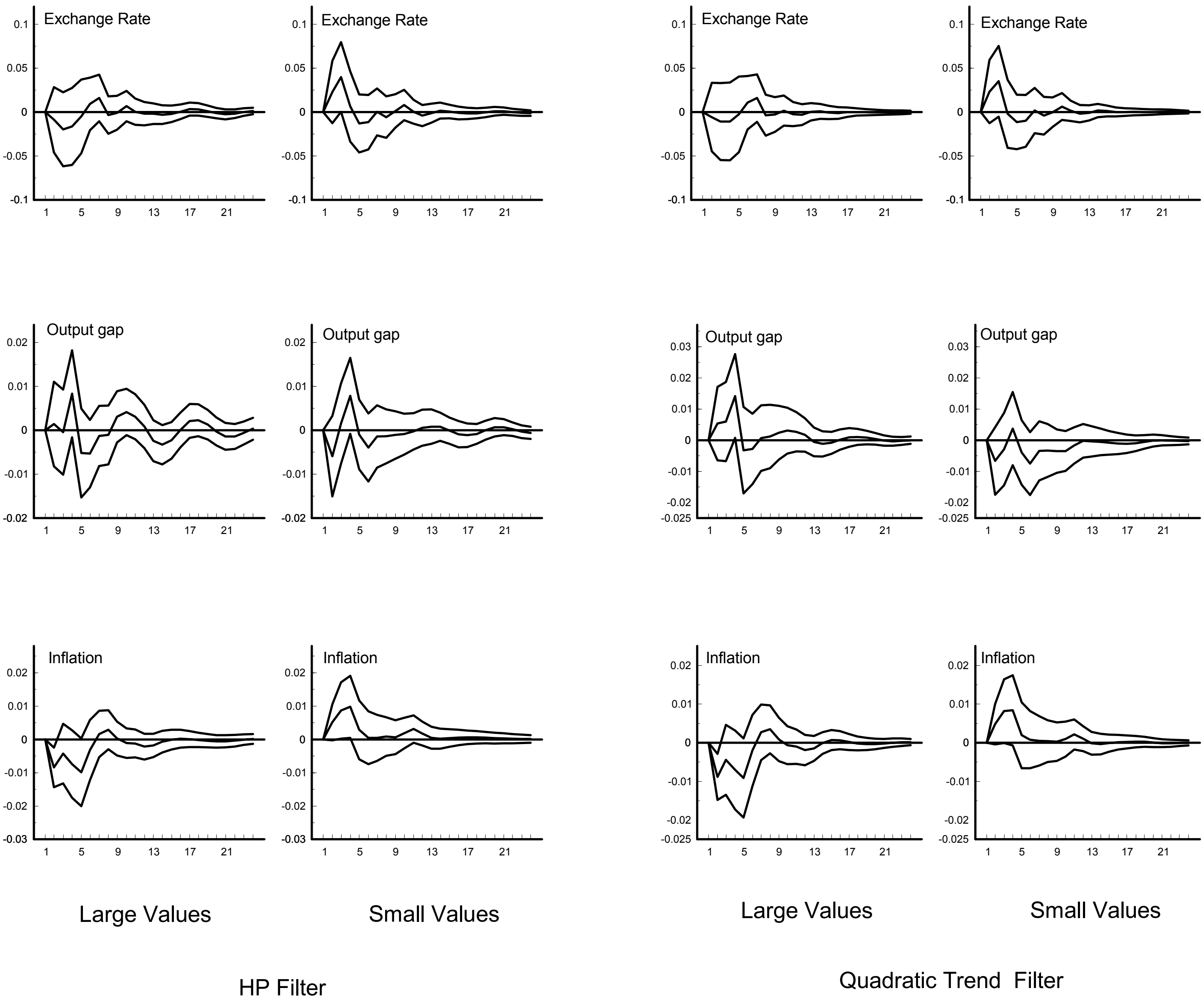


Large Values | Small Values | Large Values | Small Values

HP Filter | Quadratic Trend Filter

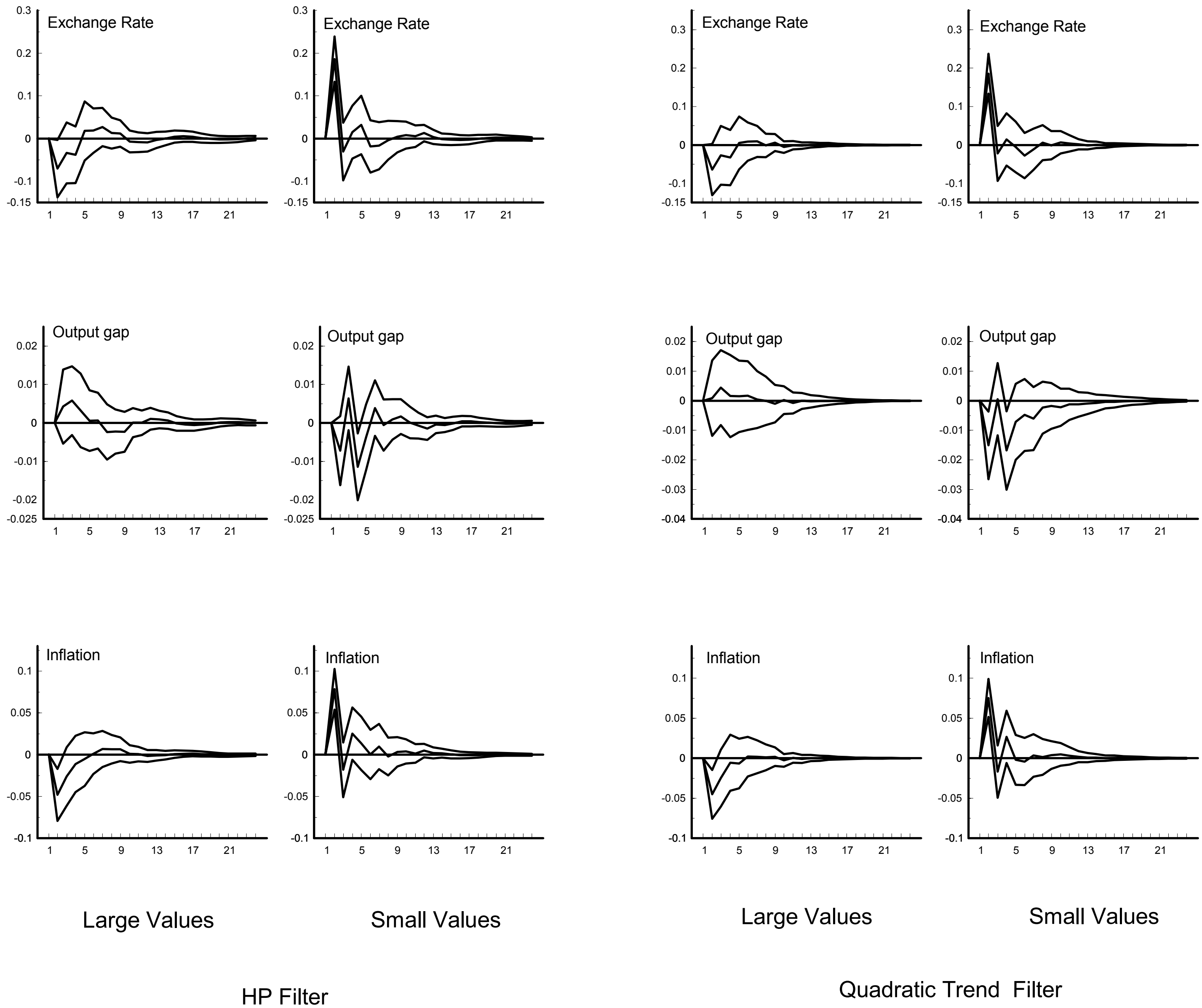
1/ Dashed lines refer to 2 standard-error bands.

Figure 4 (continued)
Asymmetric Shocks (Low and High Values of Inflation Rate)
Philippines: Response to One Standard Deviation Innovations in the Money Market Rate 1/



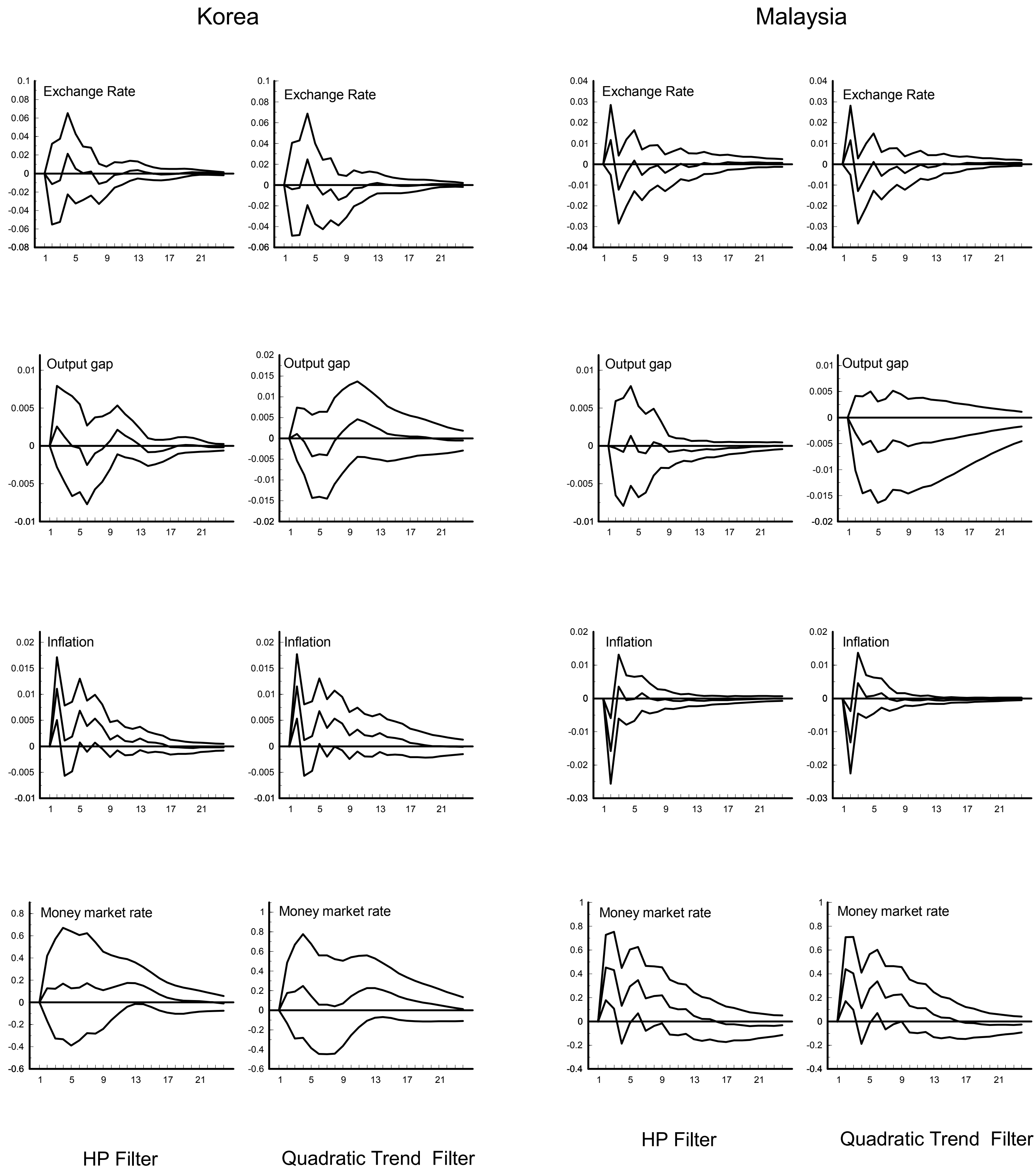
1/ Dashed lines refer to 2 standard-error bands.

Figure 4 (concluded)
Asymmetric Shocks (Low and High Values of Inflation Rate)
Turkey: Response to One Standard Deviation Innovations in the Money Market Rate 1/



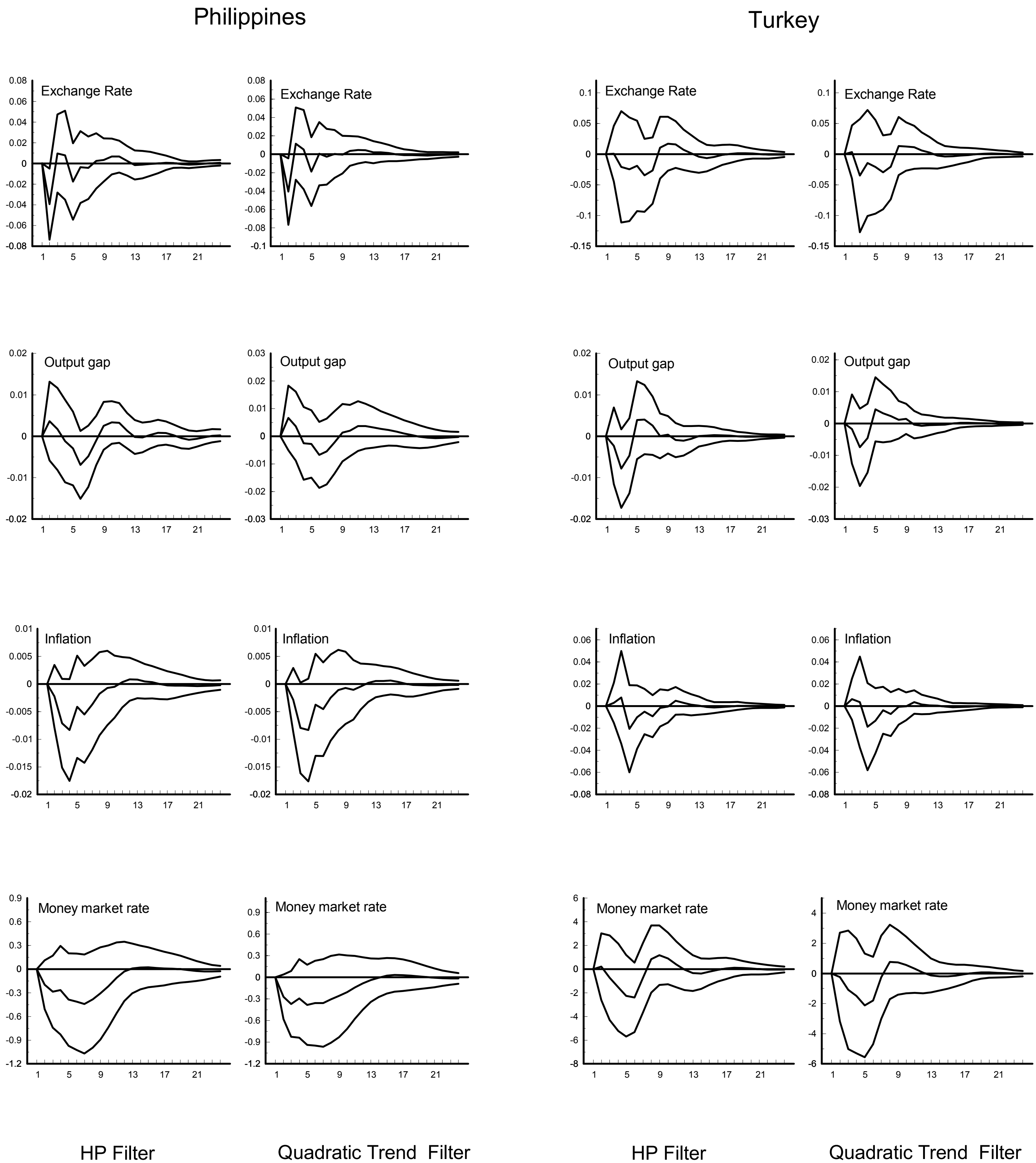
1/ Dashed lines refer to 2 standard-error bands.

Figure 5
Symmetric Shocks:
Response to One Standard Deviation Innovations in the Discount Rate 1/



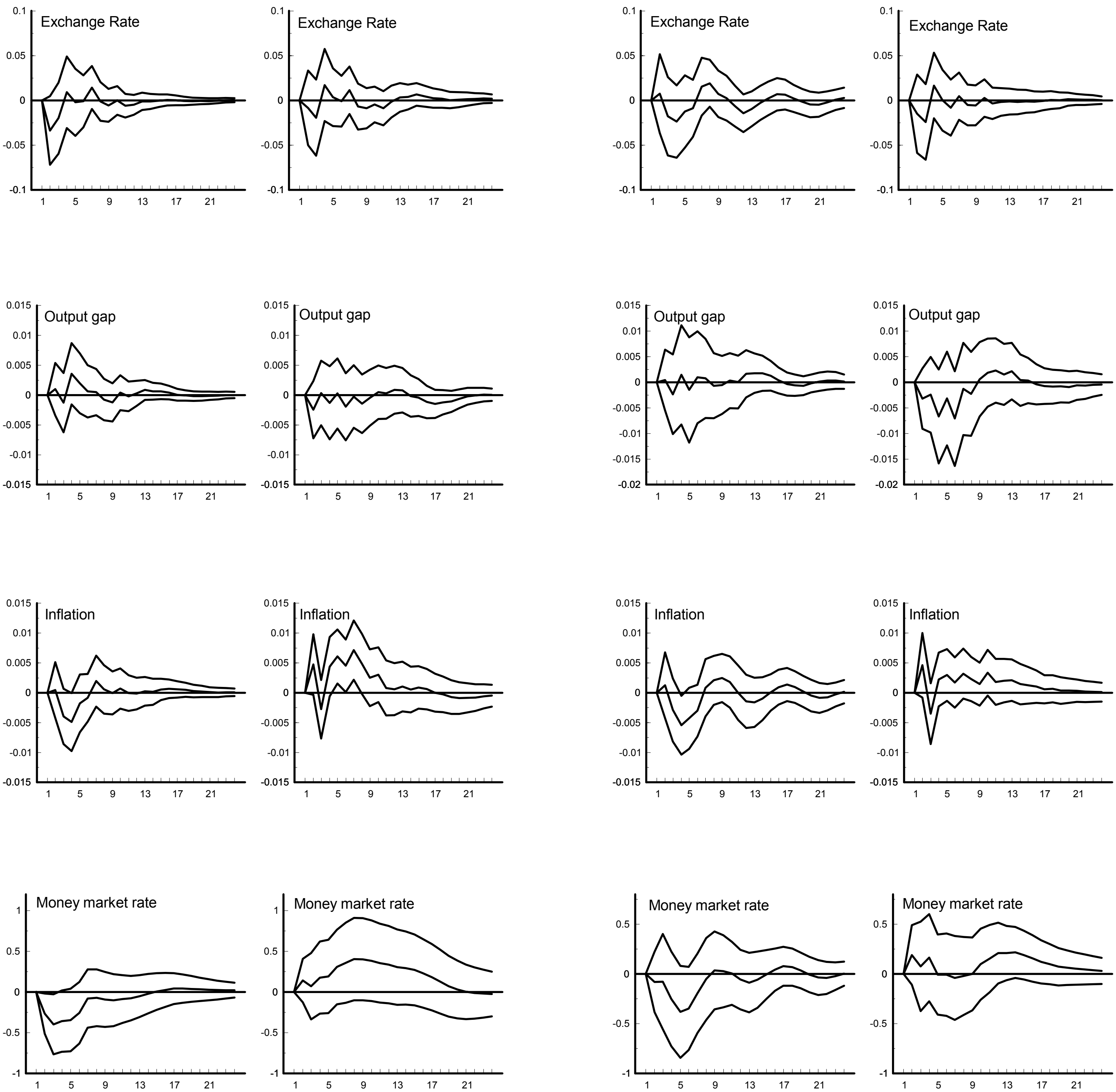
1/ Dashed lines refer to 2 standard-error bands.

Figure 5 (concluded)
Symmetric Shocks:
Response to One Standard Deviation Innovations in the Discount Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 6
Asymmetric Shocks (Positive and Negative Output Gaps)
Korea: Response to One Standard Deviation Innovations in the Discount Rate 1/

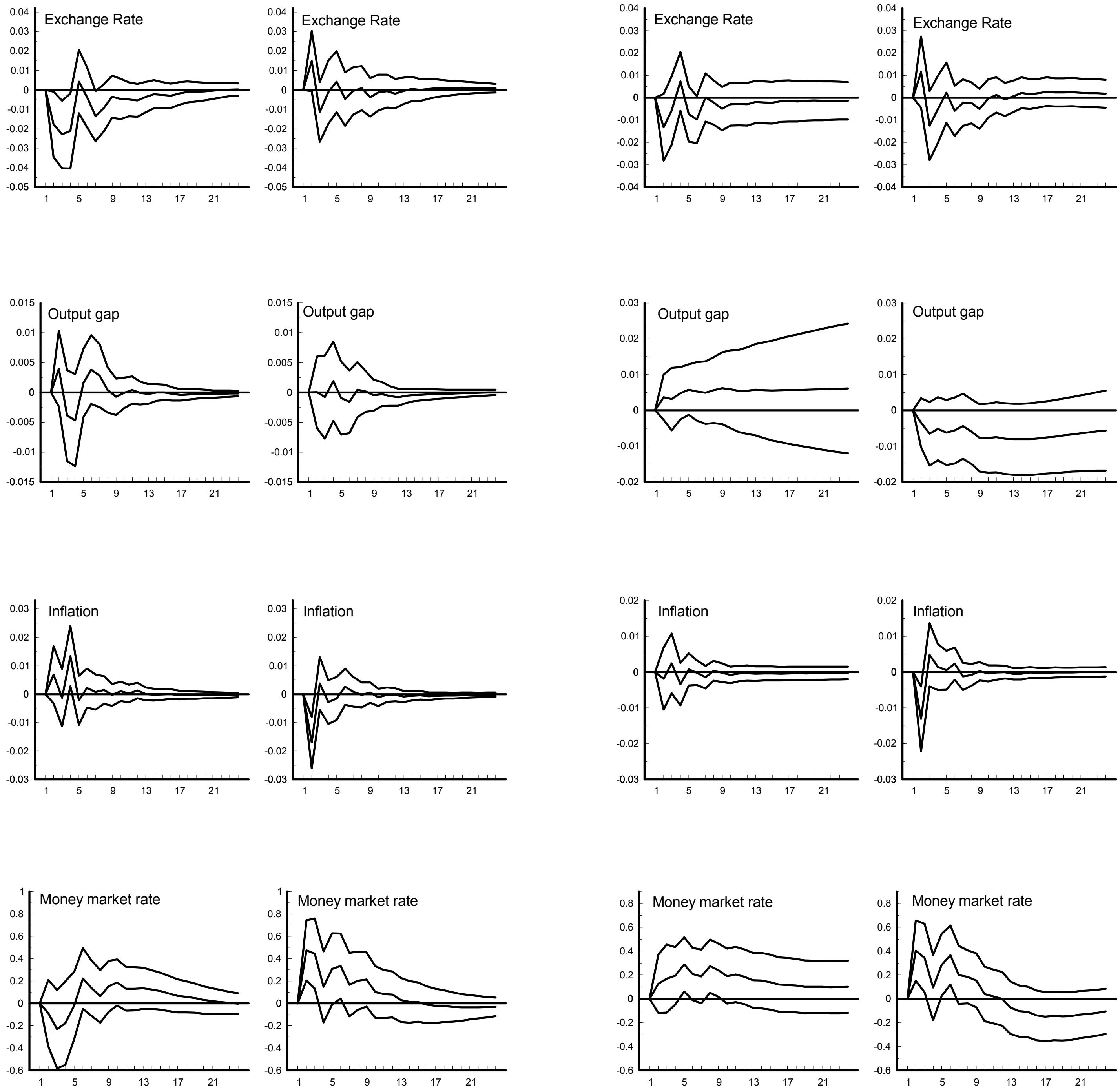


Positive Output Gap | Negative Output Gap | Positive Output Gap | Negative Output Gap

HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 6 (continued)
Asymmetric Shocks (Positive and Negative Output Gaps)
Malaysia: Response to One Standard Deviation Innovations in the Discount Rate 1/

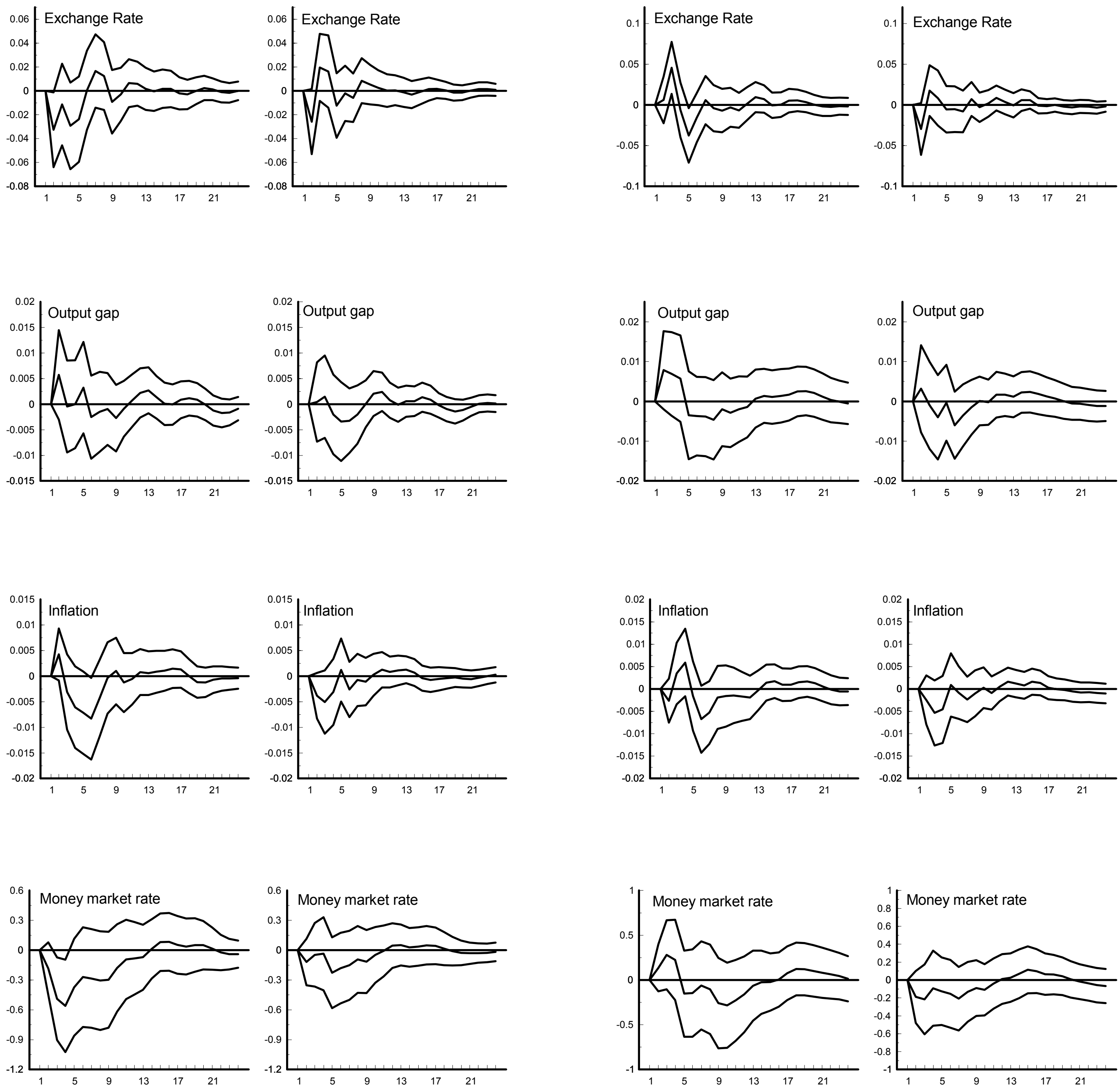


Positive Output Gap | Negative Output Gap | Positive Output Gap | Negative Output Gap

HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 6 (continued)
Asymmetric Shocks (Positive and Negative Output Gaps)
Philippines: Response to One Standard Deviation Innovations in the Discount Rate 1/

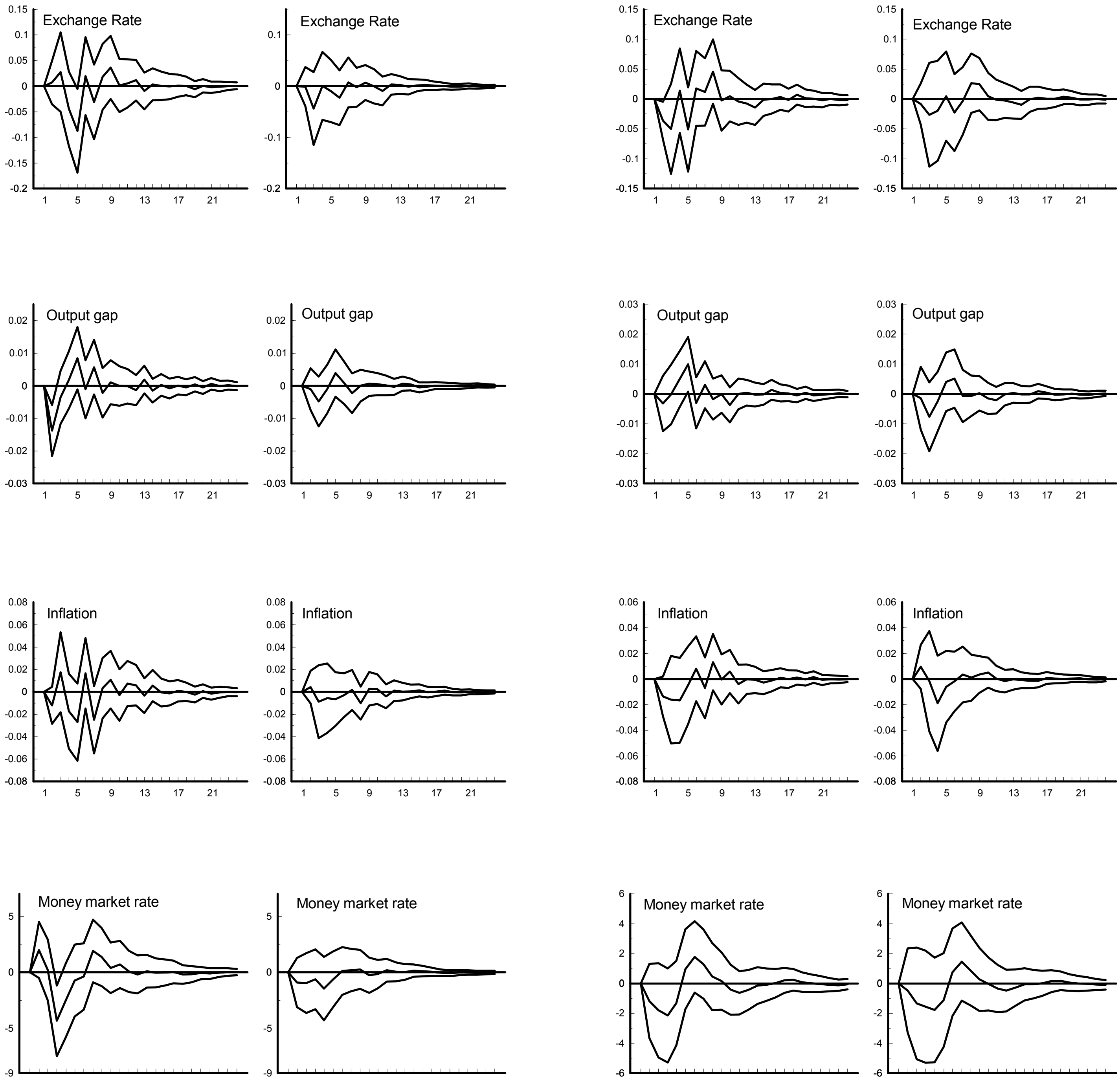


Positive Output Gap Negative Output Gap Positive Output Gap Negative Output Gap

HP Filter Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.s

Figure 6 (concluded)
Asymmetric Shocks (Positive and Negative Output Gaps)
Turkey: Response to One Standard Deviation Innovations in the Discount Rate 1/



Positive Output Gap | Negative Output Gap | Positive Output Gap | Negative Output Gap

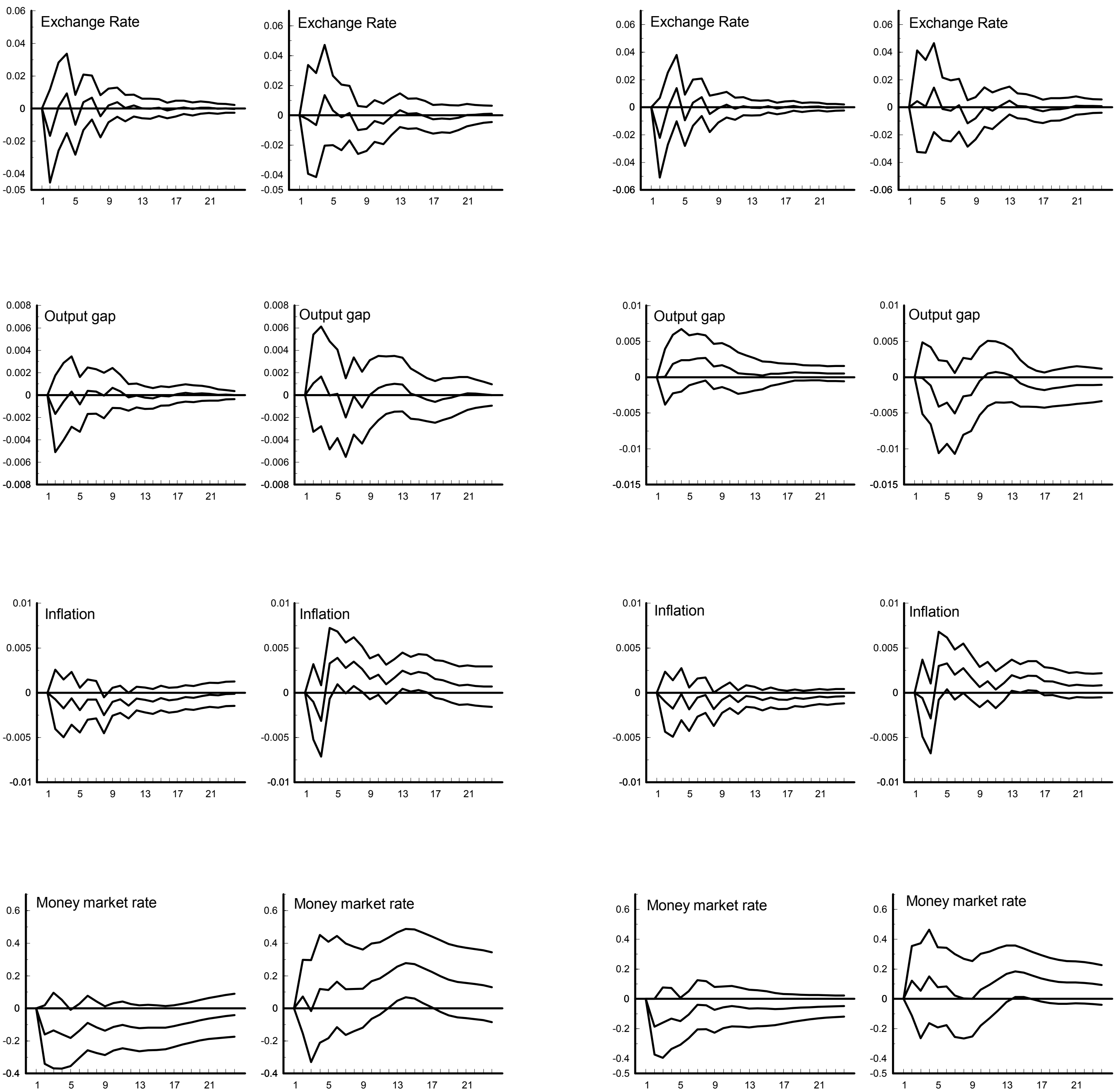
HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 7

Asymmetric Shocks (Small and Large Values of the Policy Instrument)

Korea: Response to One Standard Deviation Innovations in the Discount Rate 1/



Large Initial Values | Small Initial Values

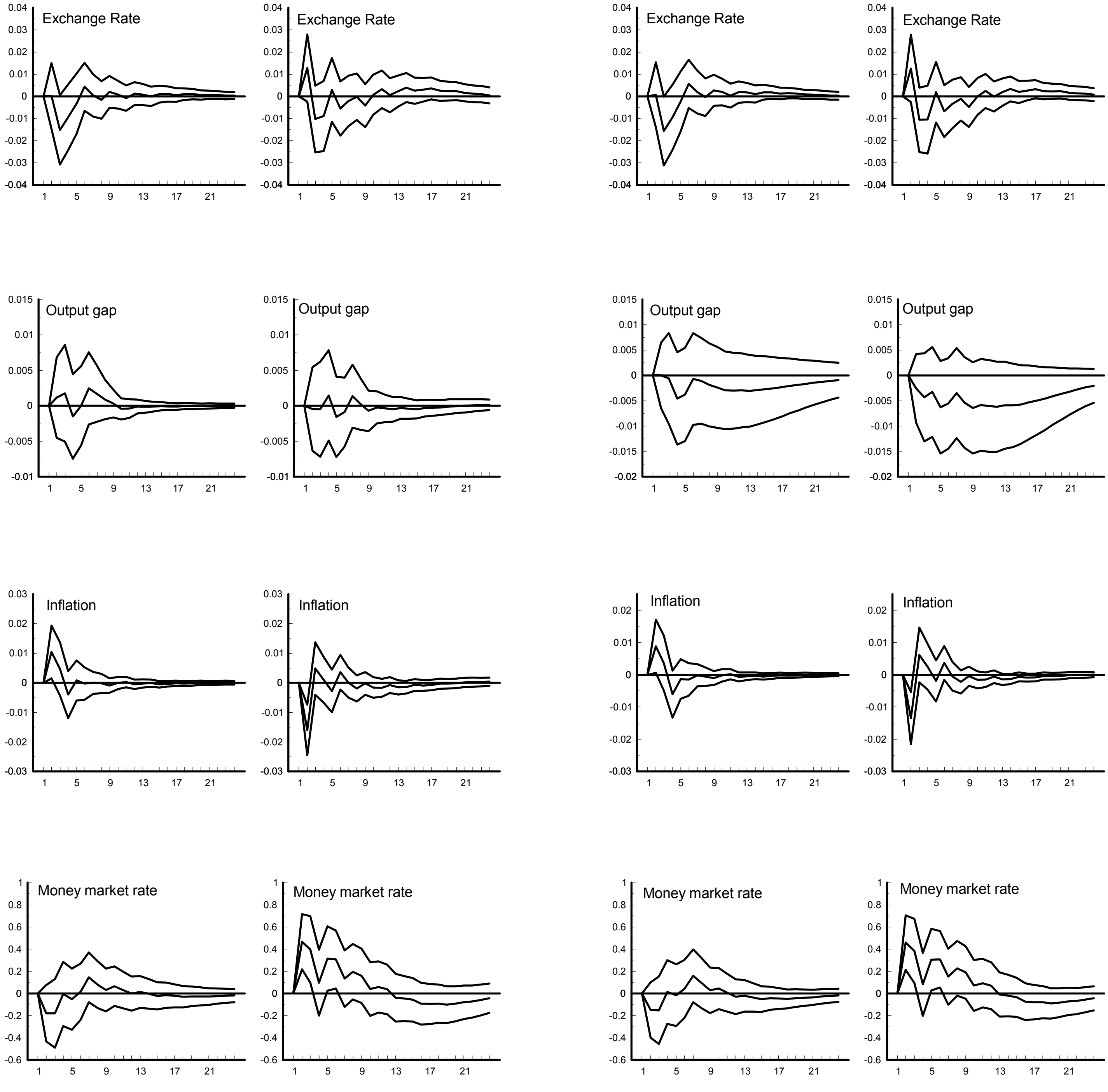
HP Filter

Large Initial Values | Small Initial Values

Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 7 (continued)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Malaysia: Response to One Standard Deviation Innovations in the Discount Rate 1/

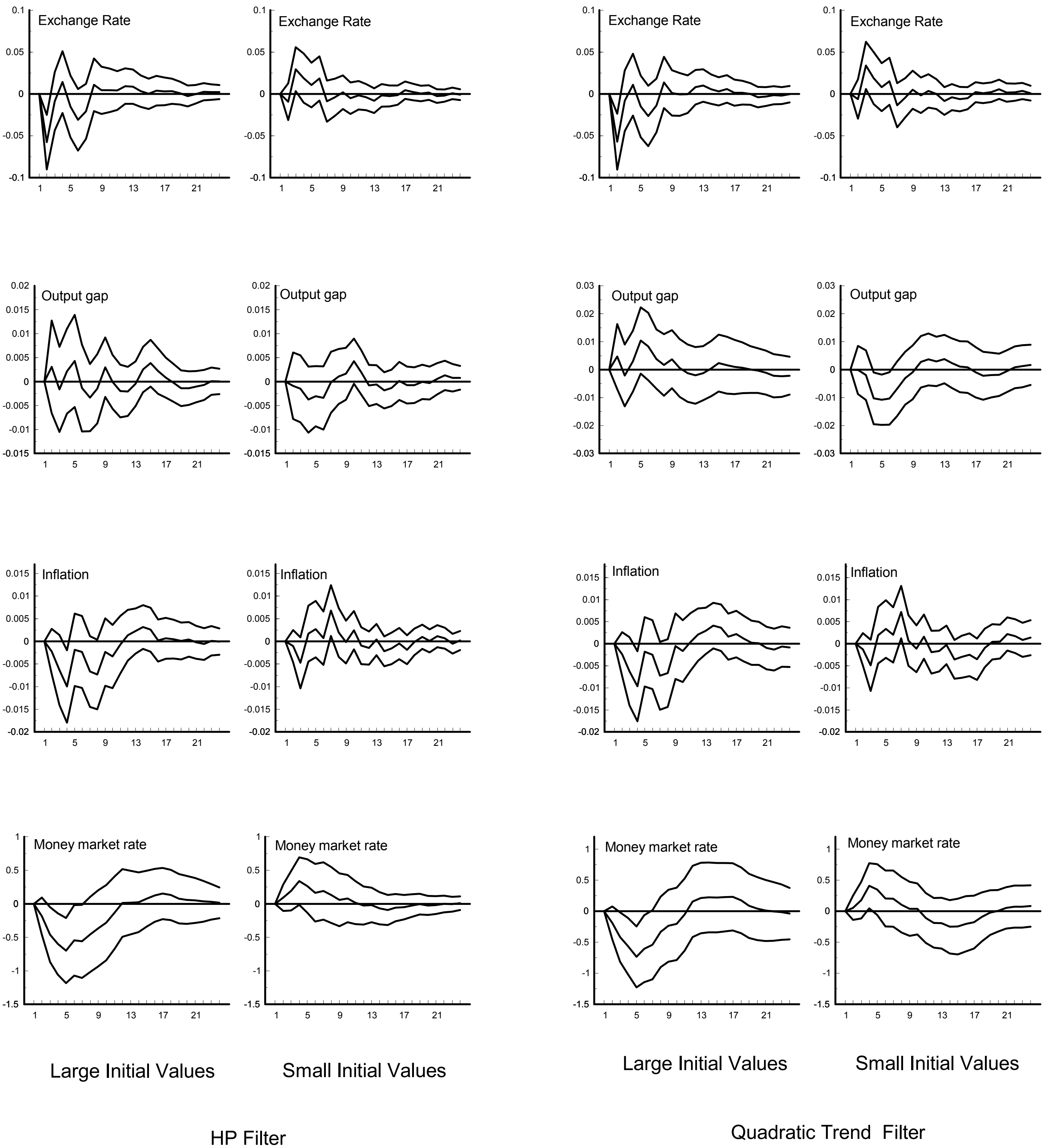


Large Initial Values | Small Initial Values | Large Initial Values | Small Initial Values

HP Filter | Quadratic Trend Filter

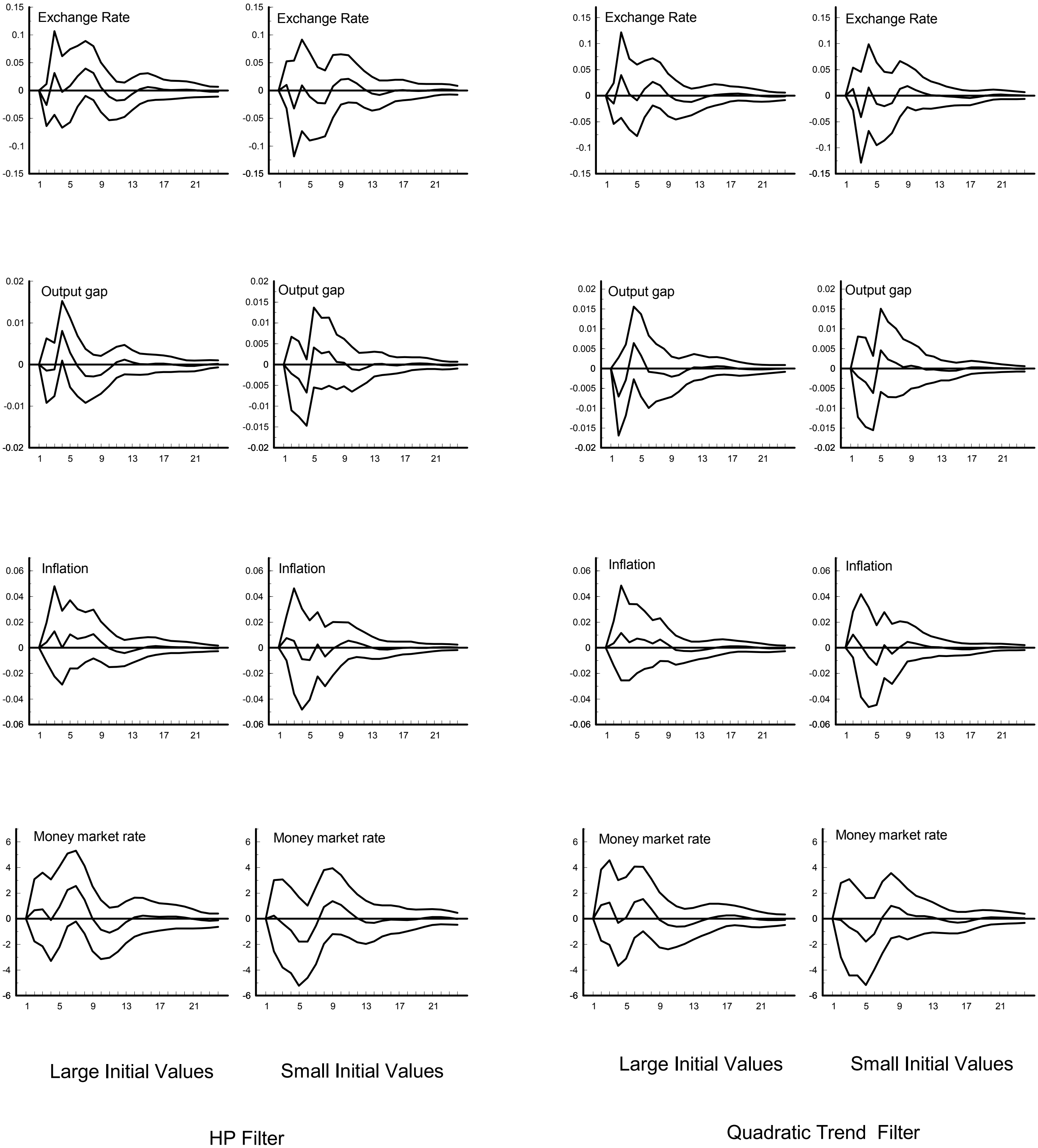
1/ Dashed lines refer to 2 standard-error bands.

Figure 7 (continued)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Philippines: Response to One Standard Deviation Innovations in the Discount Rate 1/



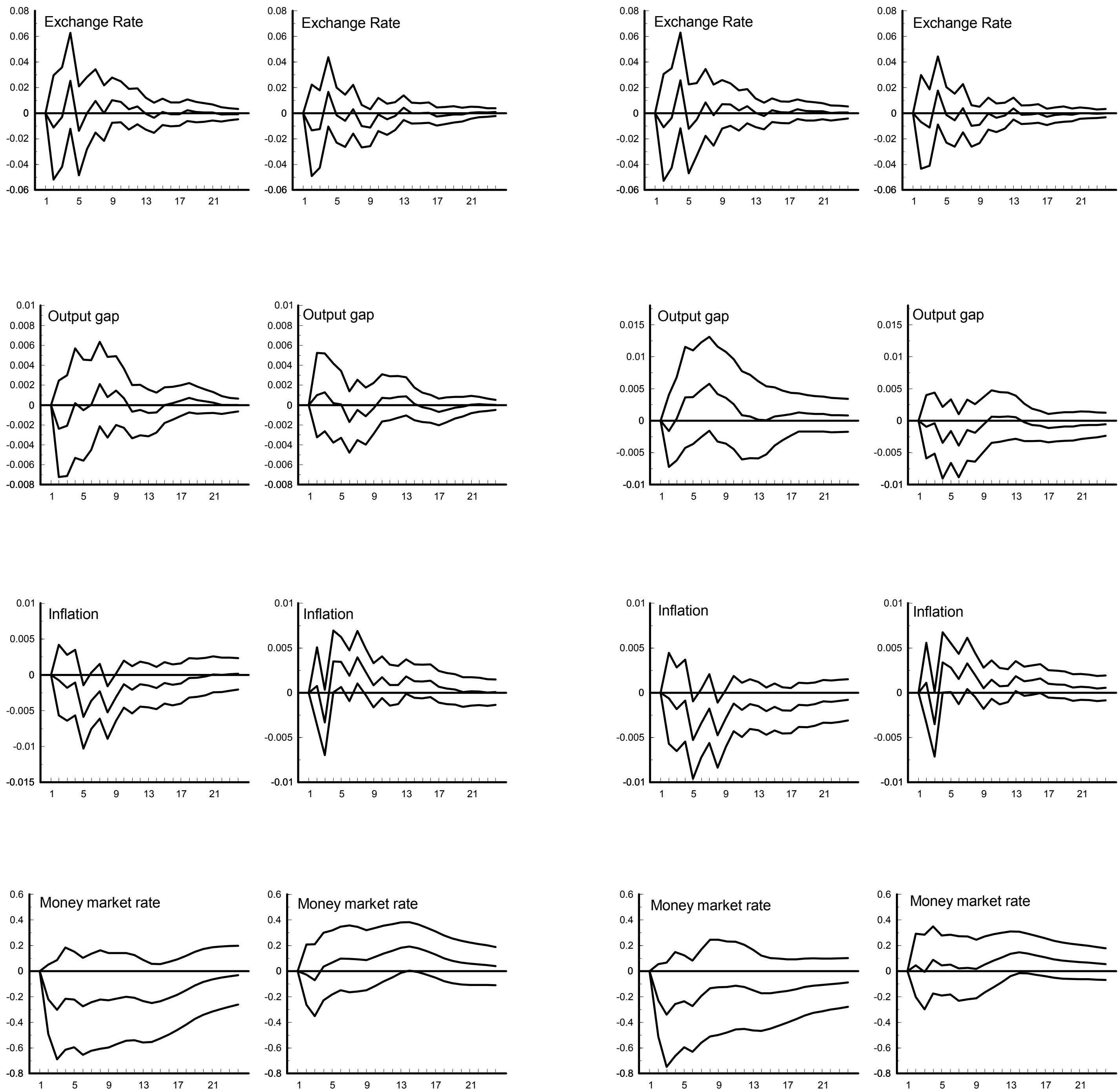
1/ Dashed lines refer to 2 standard-error bands.

Figure 7 (concluded)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Turkey: Response to One Standard Deviation Innovations in the Discount Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 8
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Korea: Response to One Standard Deviation Innovations in the Discount Rate 1/

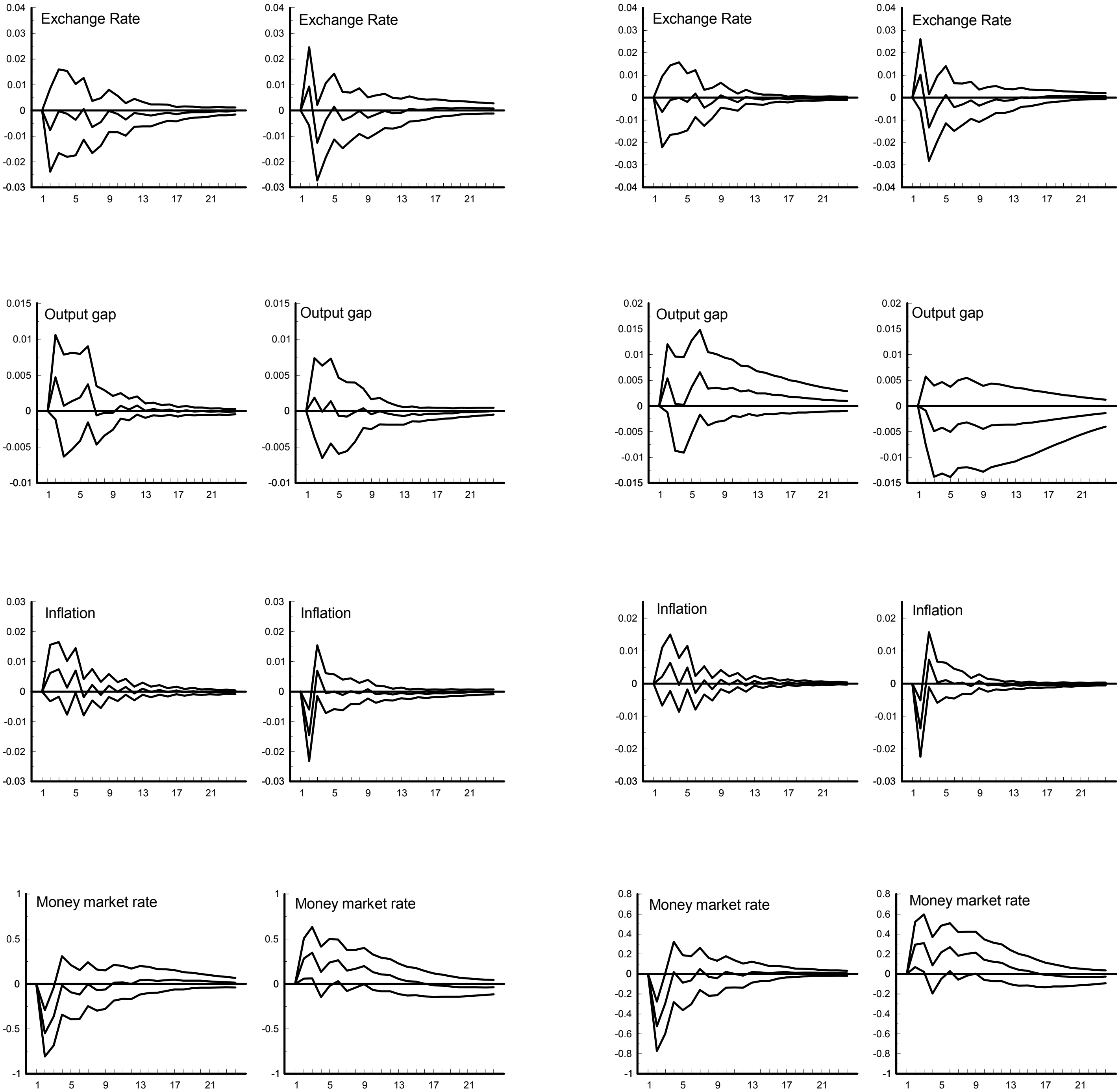


Large Values Small Values Large Values Small Values

HP Filter Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 8 (continued)
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Malaysia: Response to One Standard Deviation Innovations in the Discount Rate 1/

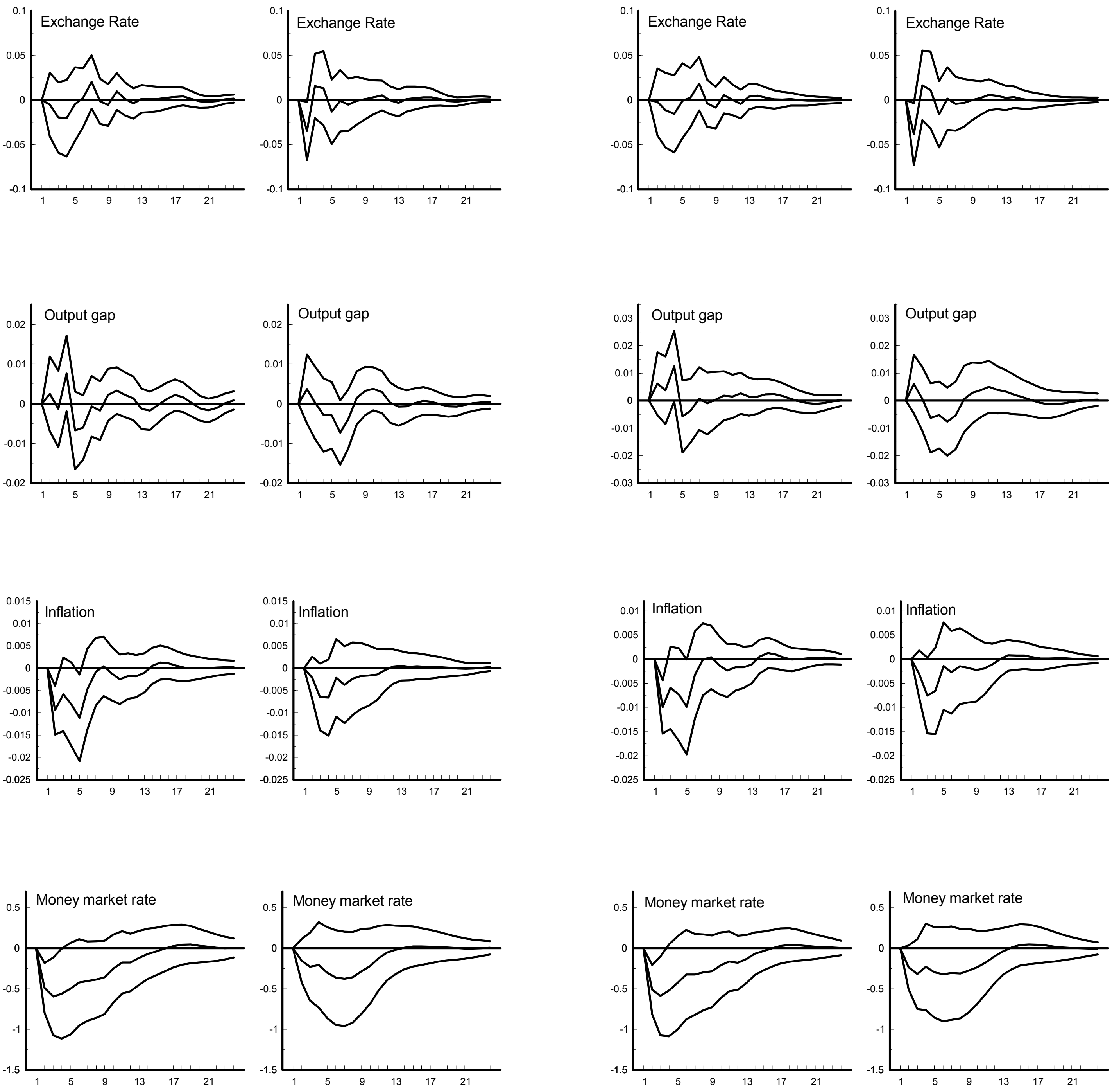


Large Values | Small Values | Large Values | Small Values

HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 8 (continued)
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Philippines: Response to One Standard Deviation Innovations in the Discount Rate 1/

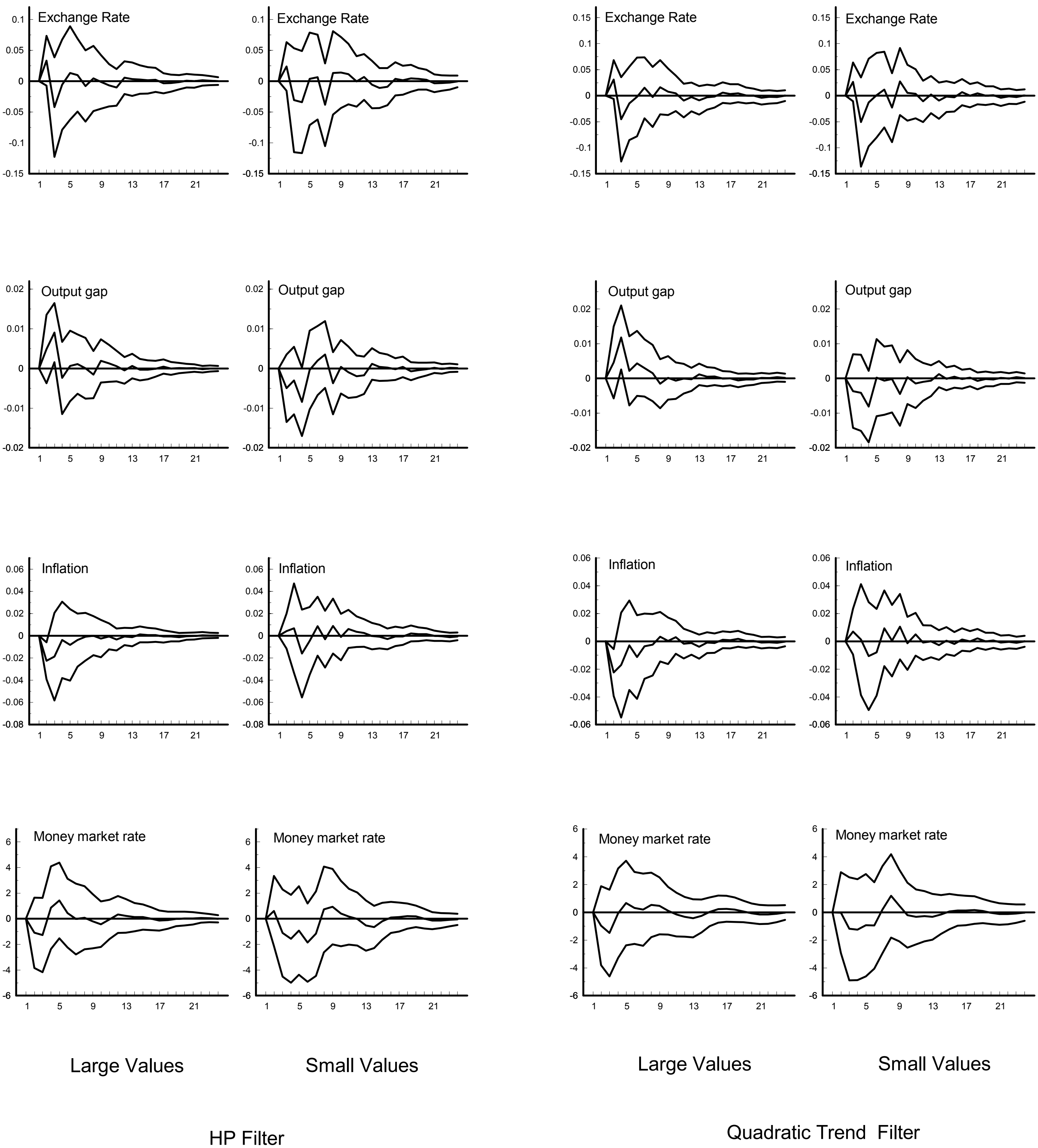


Large Values Small Values Large Values Small Values

HP Filter Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

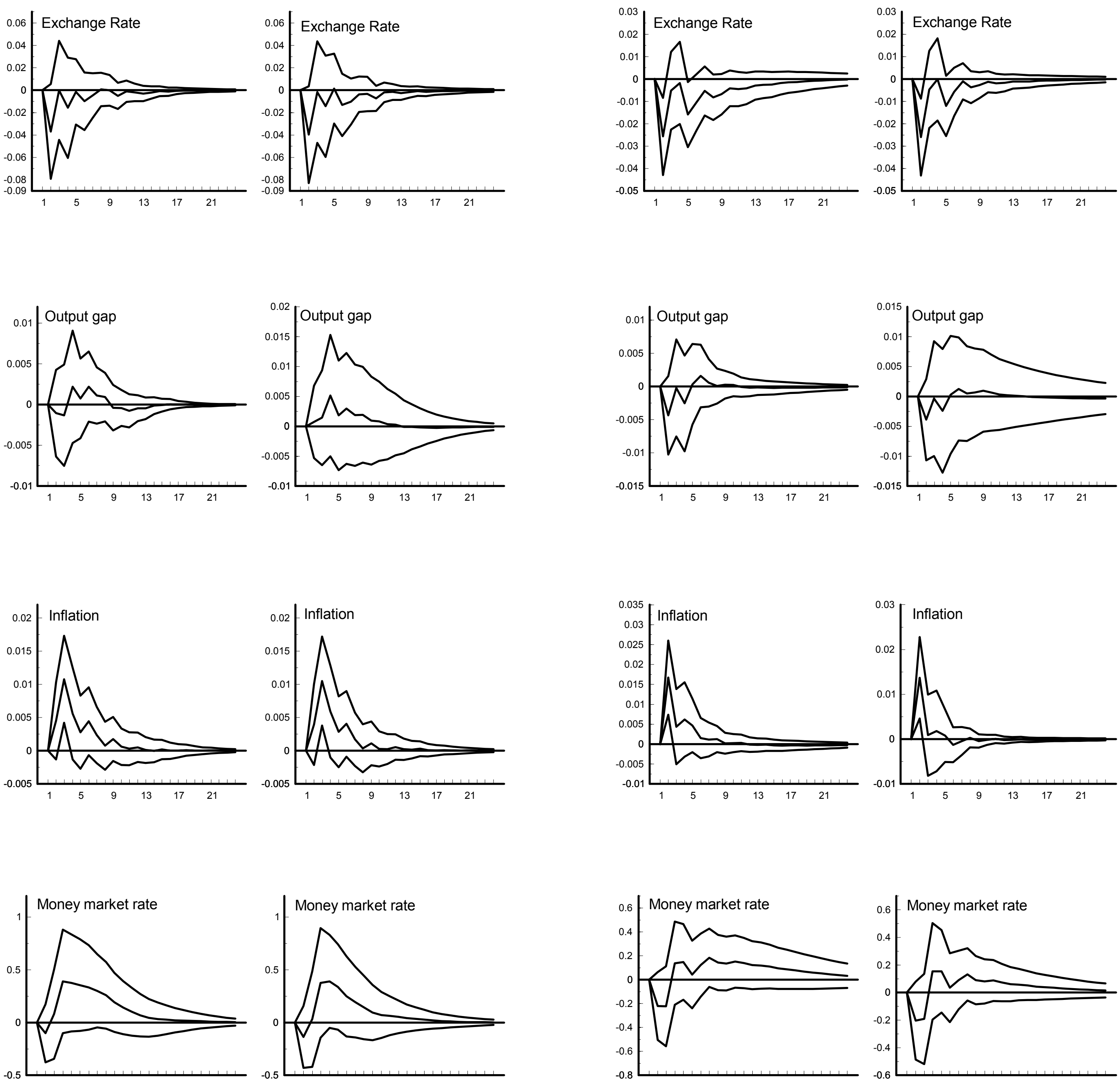
Figure 8 (concluded)
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Turkey: Response to One Standard Deviation Innovations in the Discount Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 9
Symmetric Shocks:
Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

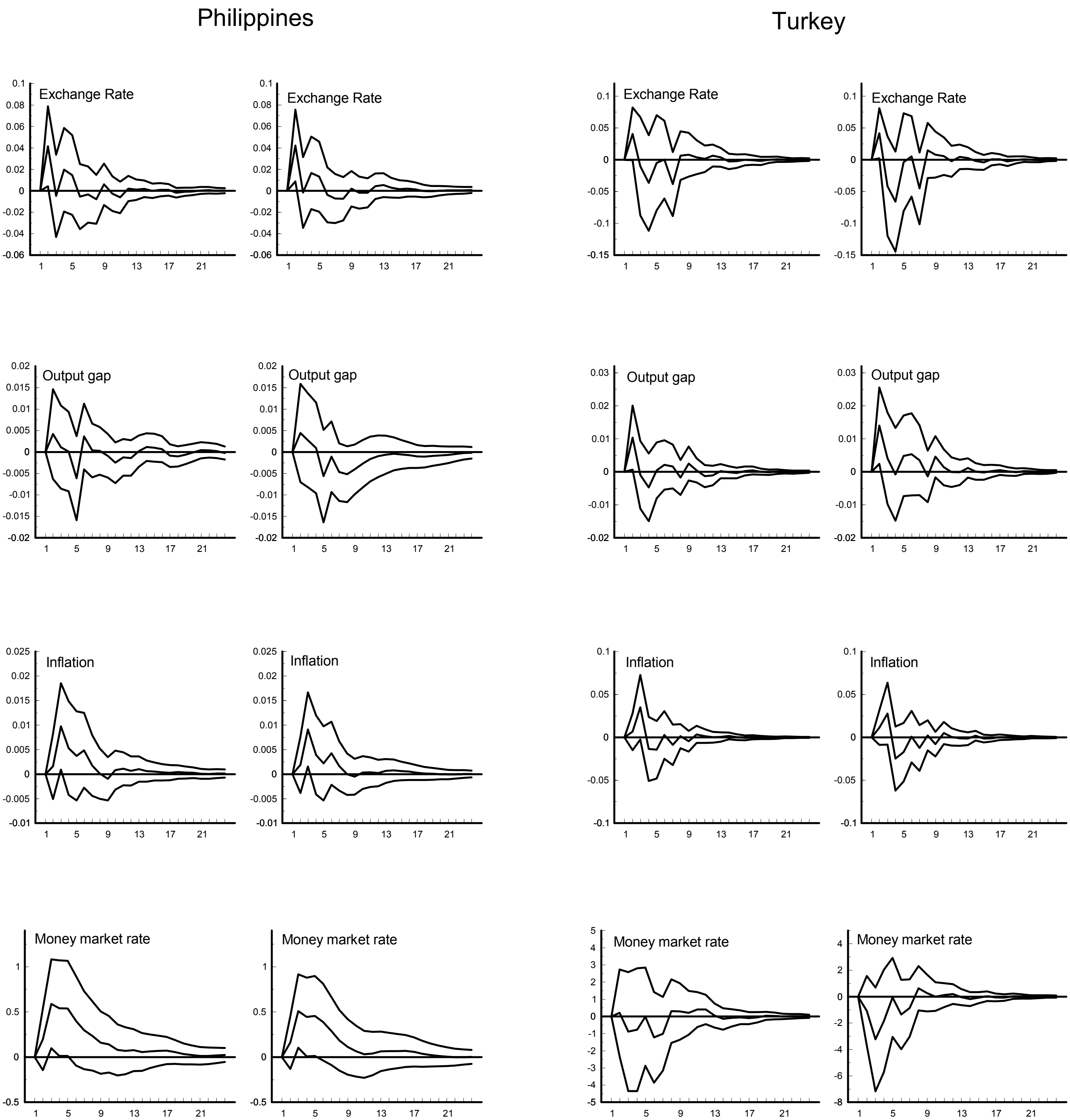
Korea | Malaysia



HP Filter | Quadratic Trend Filter | HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

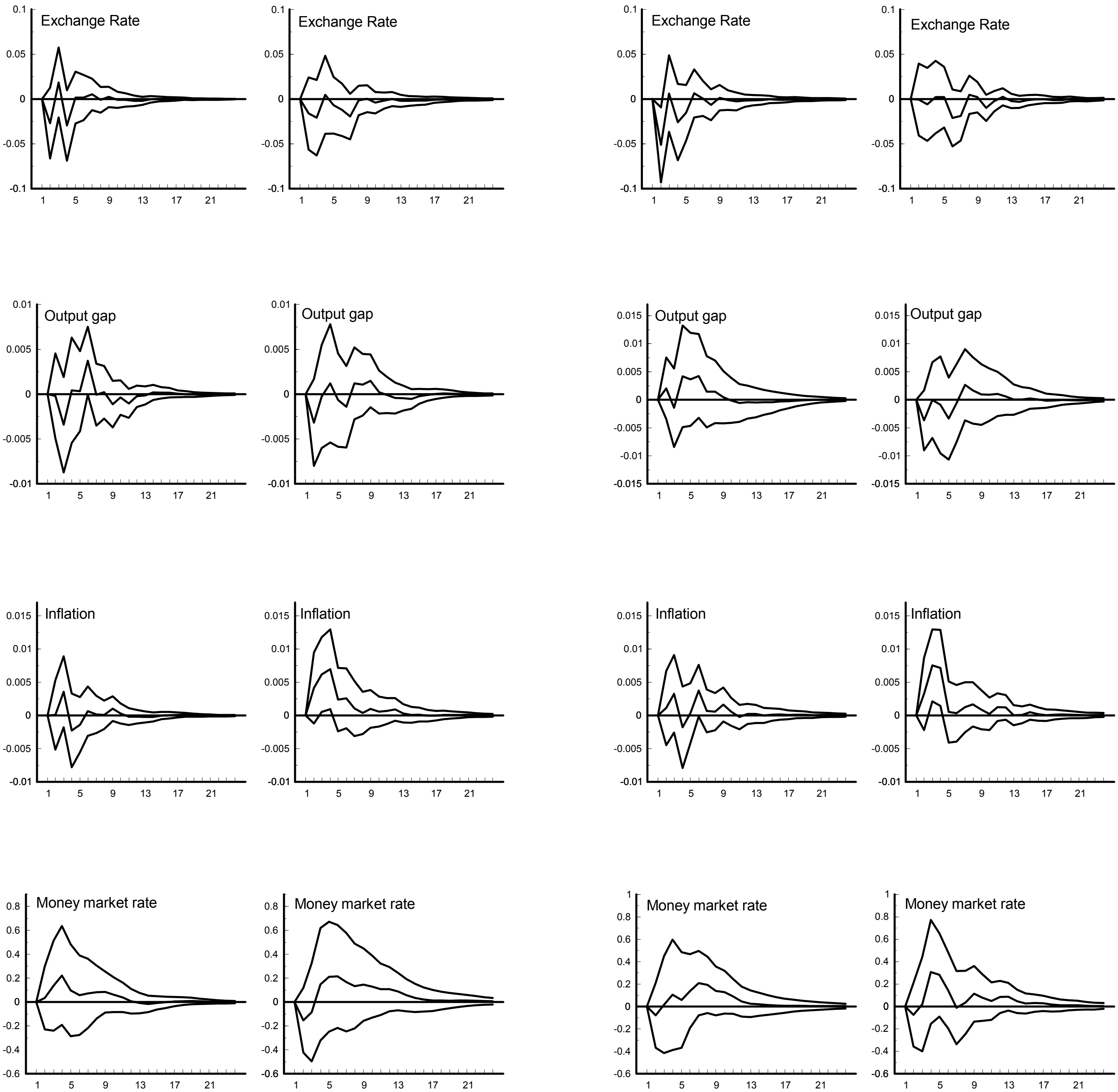
Figure 9 (concluded)
Symmetric Shocks:
Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/



HP Filter Quadratic Trend Filter HP Filter Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 10
Asymmetric Shocks (Positive and Negative Output Gaps)
Korea: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

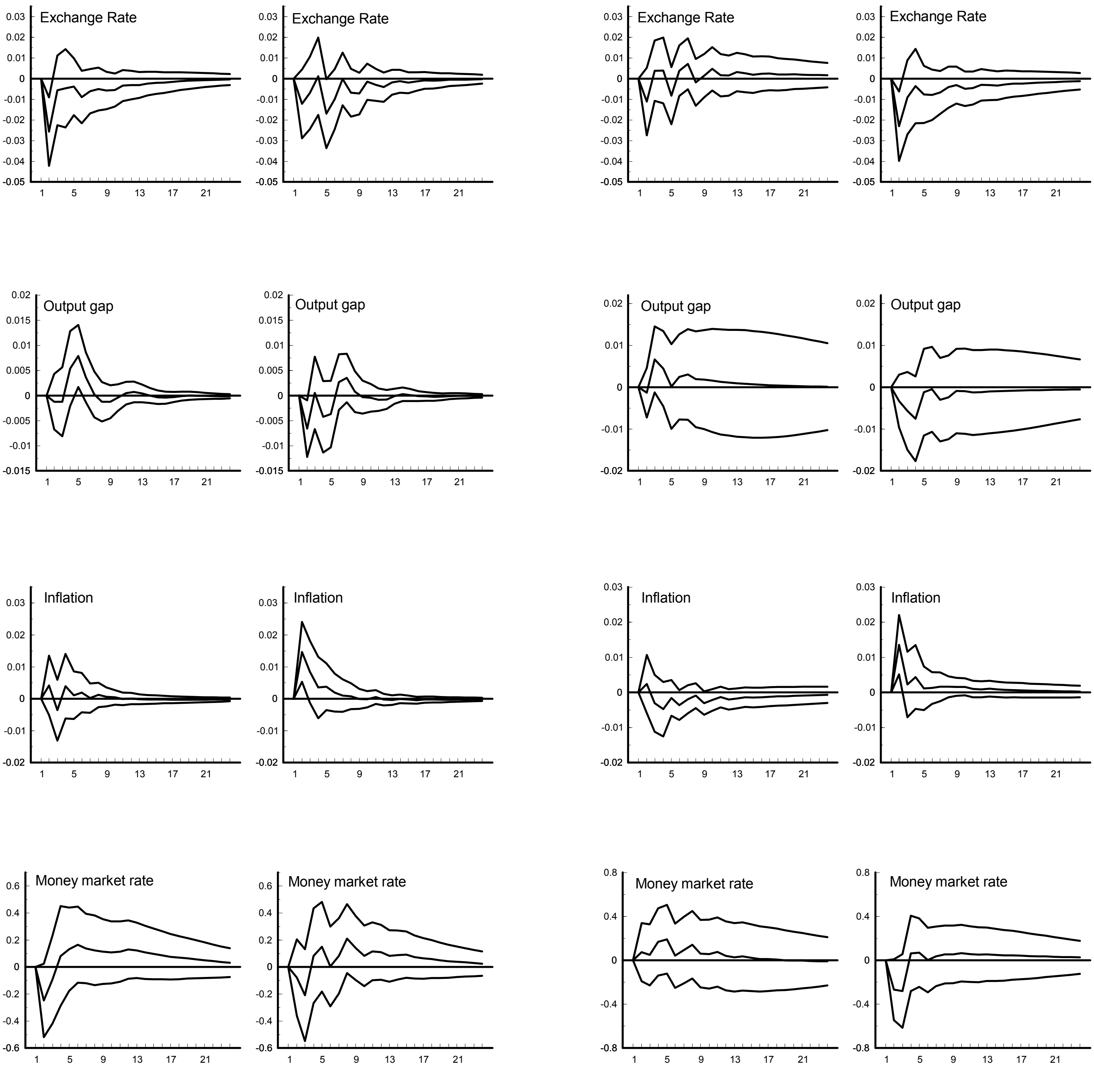


Positive Output Gap Negative Output Gap Positive Output Gap Negative Output Gap

HP Filter Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 10 (continued)
Asymmetric Shocks (Positive and Negative Output Gaps)
Malaysia: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

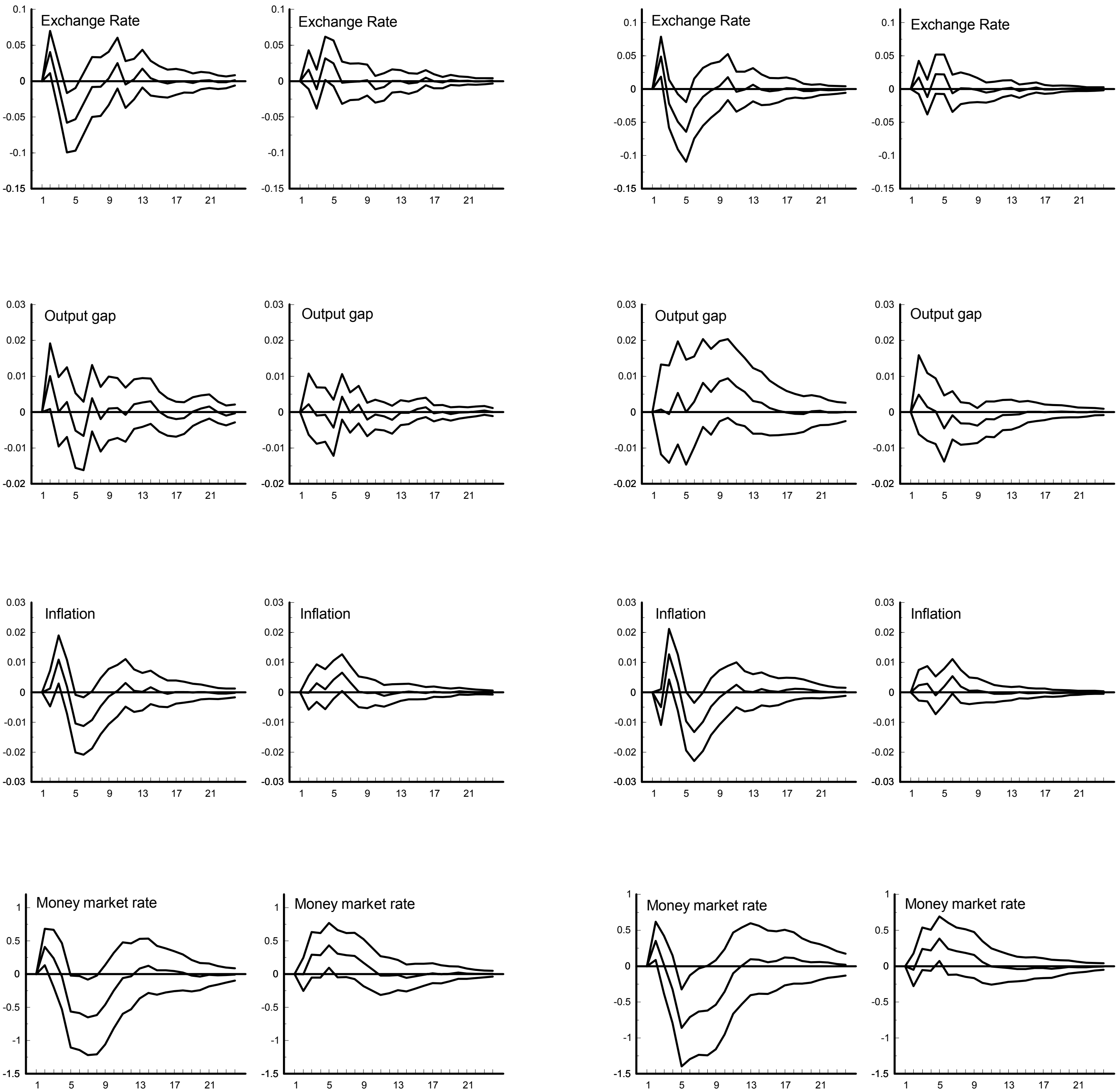


Positive Output Gap | Negative Output Gap | Positive Output Gap | Negative Output Gap

HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 10 (continued)
Asymmetric Shocks (Positive and Negative Output Gaps)
Philippines: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

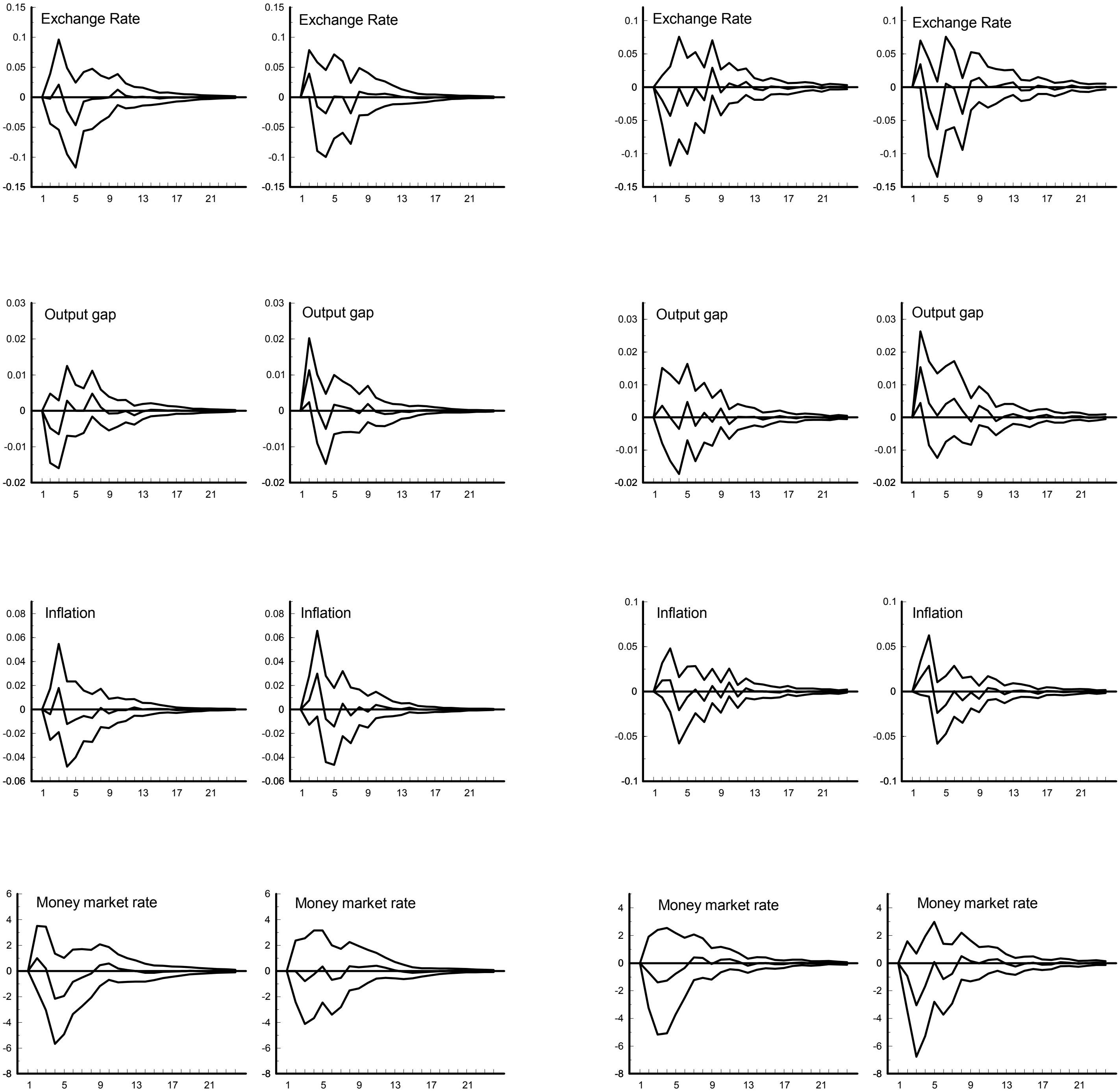


Positive Output Gap Negative Output Gap Positive Output Gap Negative Output Gap

HP Filter Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 10 (concluded)
Asymmetric Shocks (Positive and Negative Output Gaps)
Turkey: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

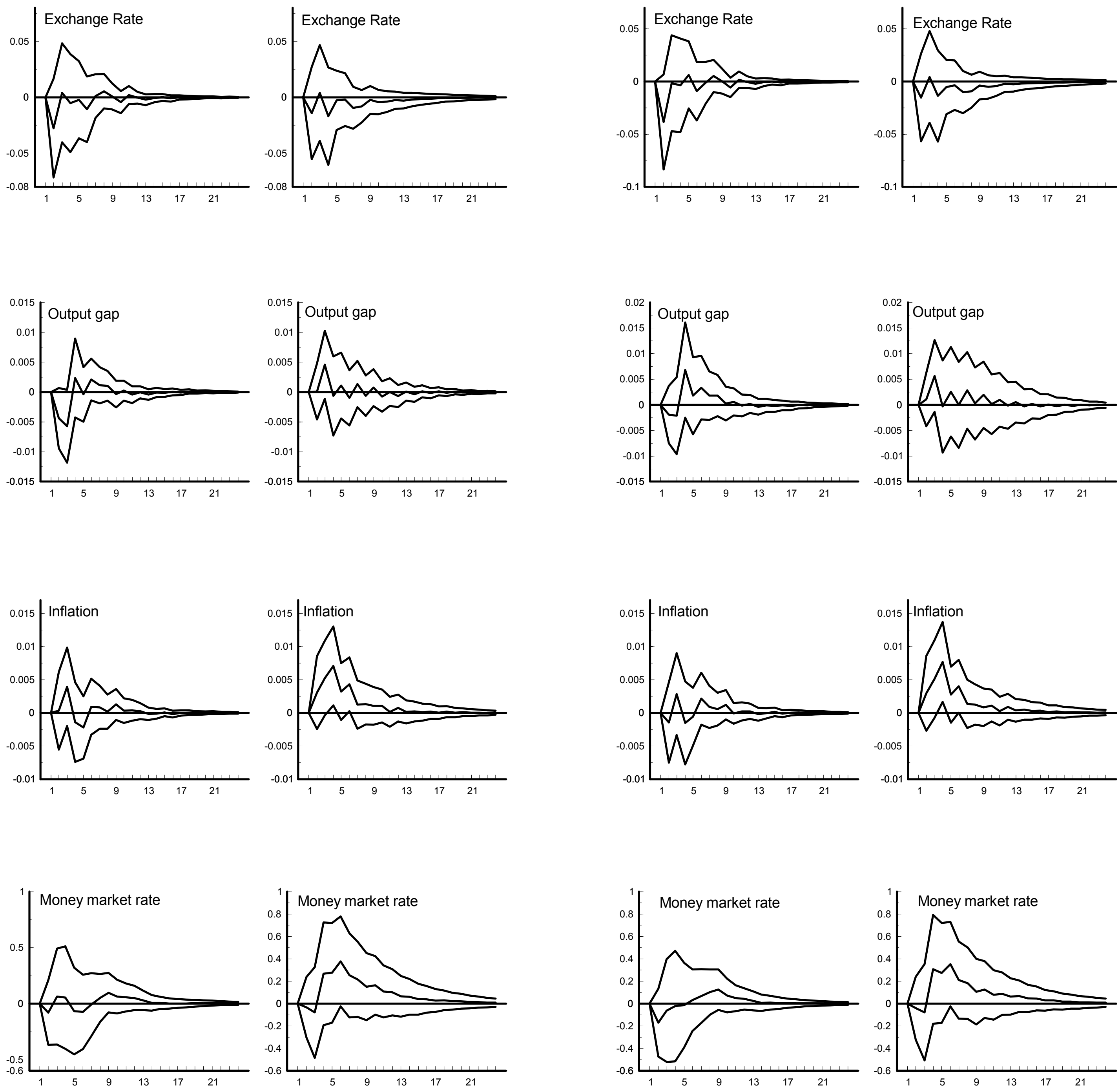


Positive Output Gap Negative Output Gap Positive Output Gap Negative Output Gap

HP Filter Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 11
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Korea: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

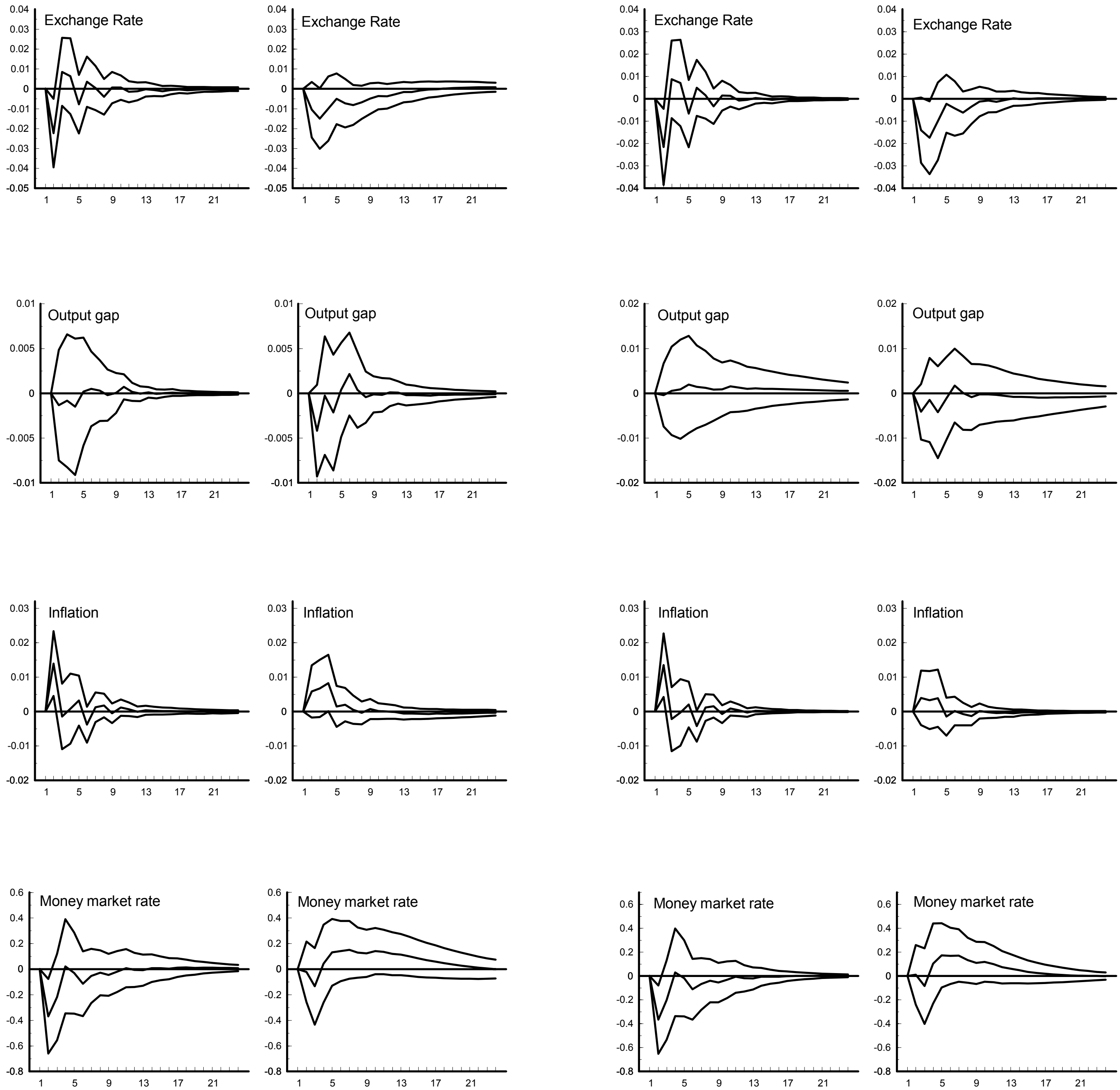


Large Initial Values | Small Initial Values | Large Initial Values | Small Initial Values

HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 11 (continued)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Malaysia: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

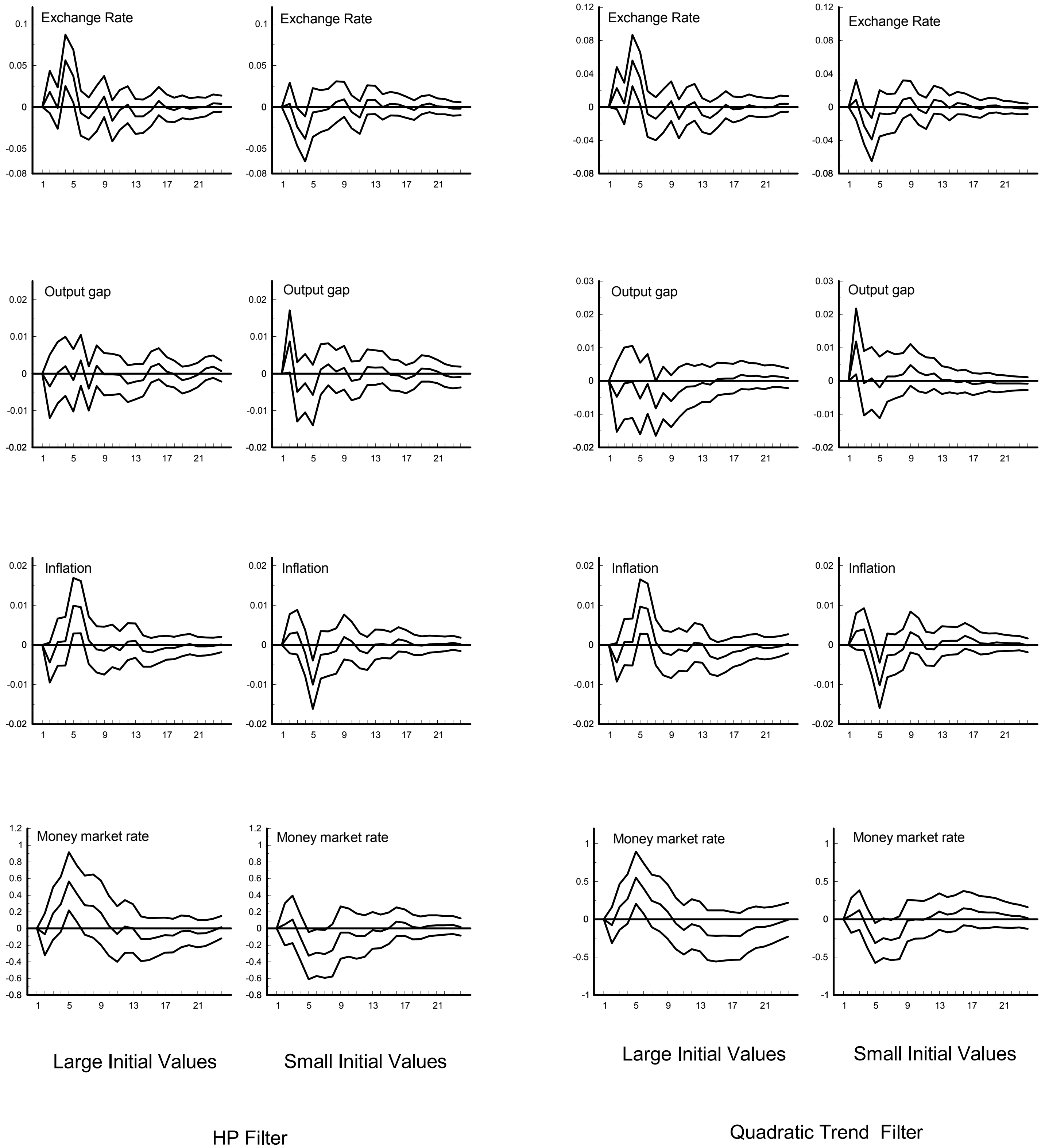


Large Initial Values   Small Initial Values   Large Initial Values   Small Initial Values

HP Filter   Quadratic Trend Filter

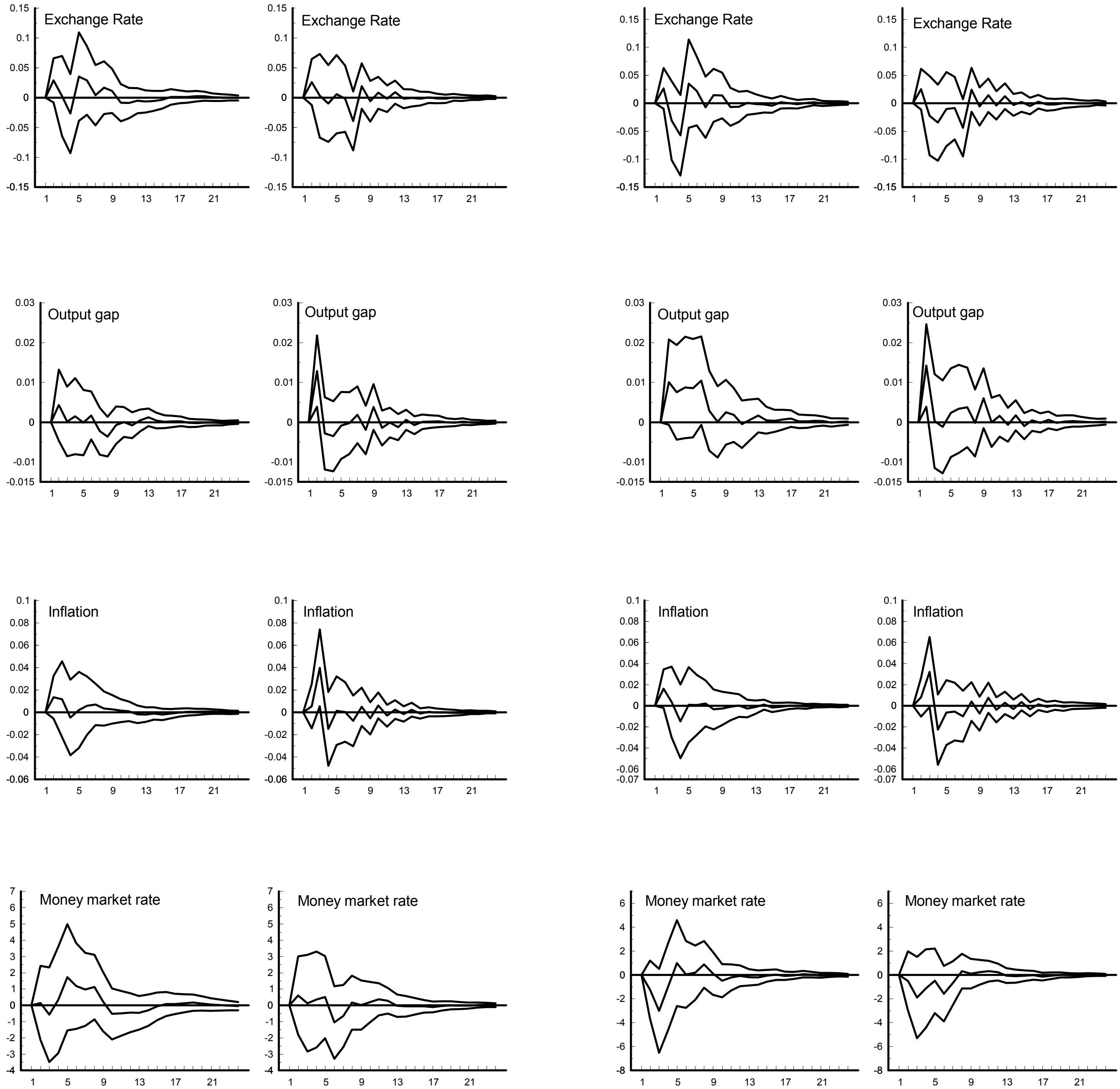
1/ Dashed lines refer to 2 standard-error bands.

Figure 11 (continued)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Philippines: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 11 (concluded)
Asymmetric Shocks (Small and Large Values of the Policy Instrument)
Turkey: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

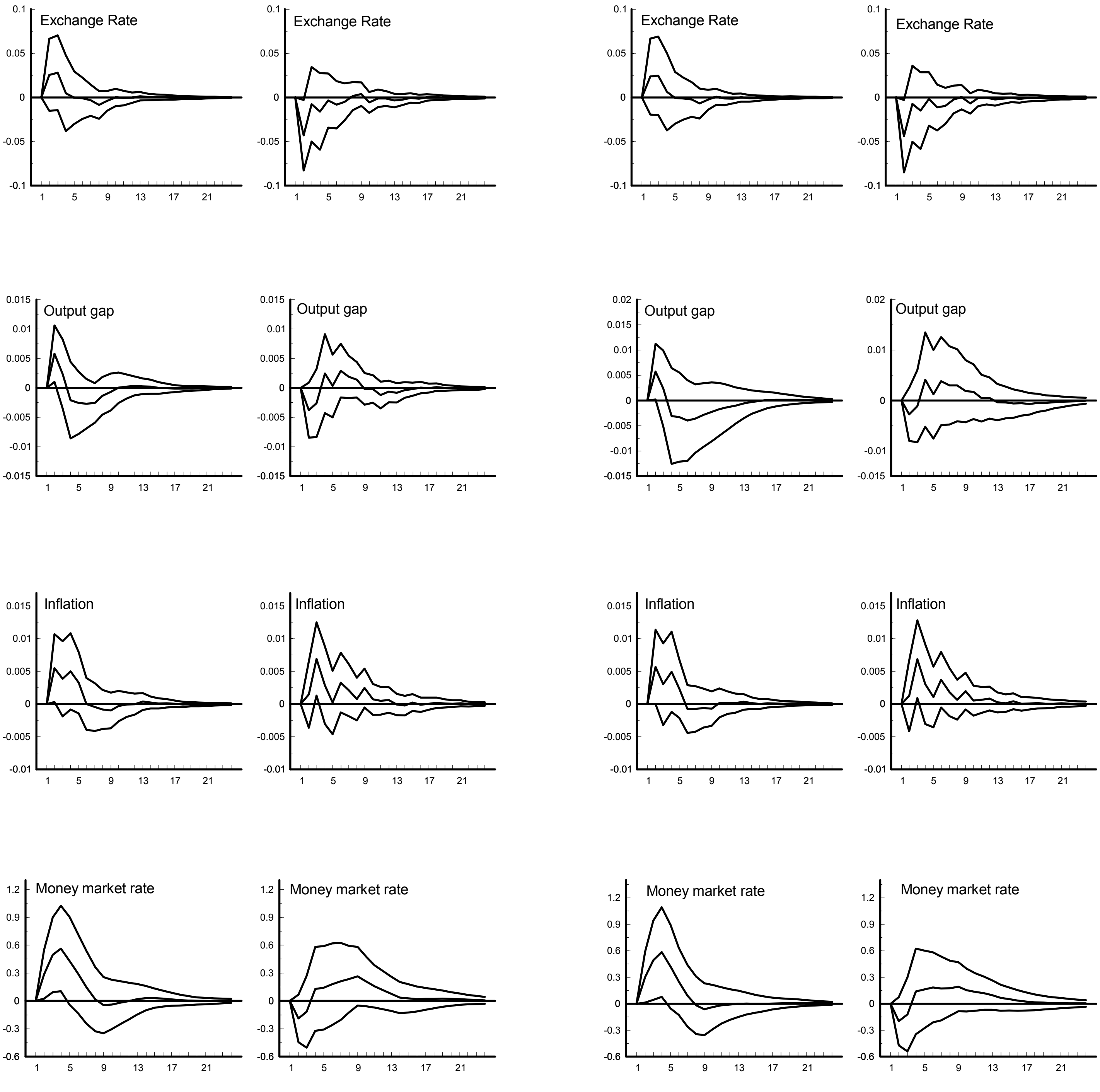


Large Initial Values | Small Initial Values | Large Initial Values | Small Initial Values

HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Figure 12
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Korea: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/

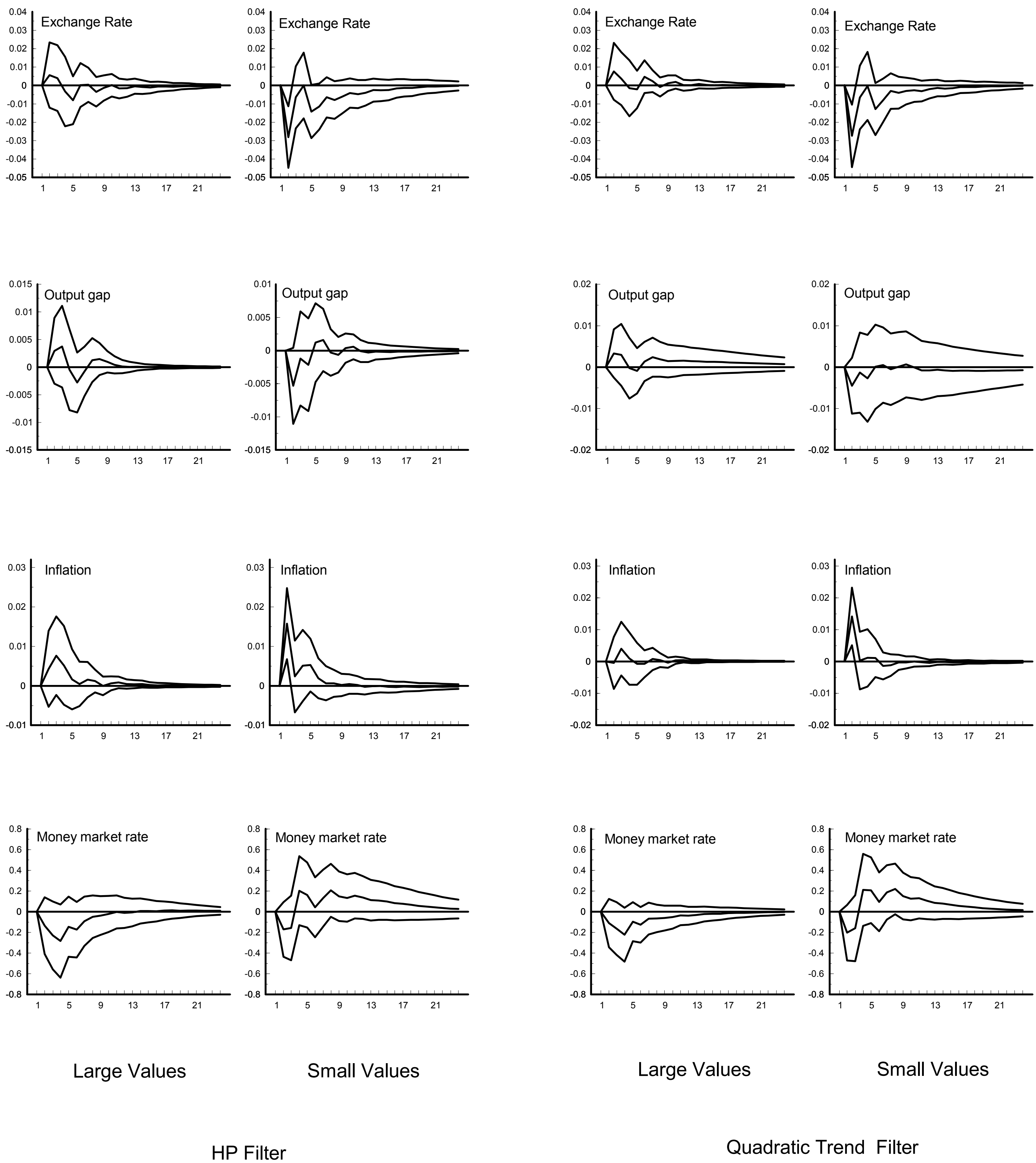


Large Values Small Values Large Values Small Values

HP Filter Quadratic Trend Filter

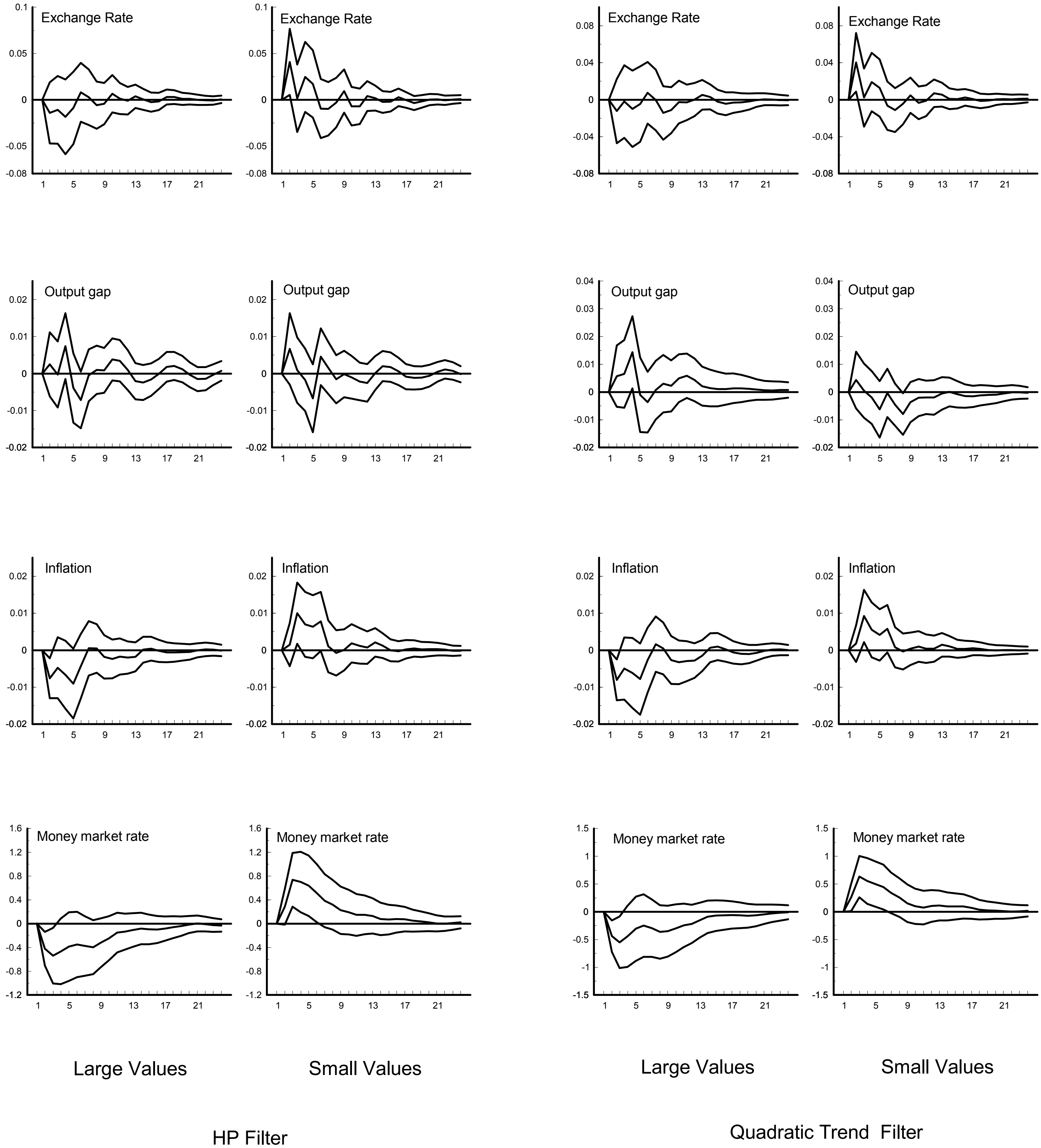
1/ Dashed lines refer to 2 standard-error bands.

Figure 12 (continued)
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Malaysia: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/



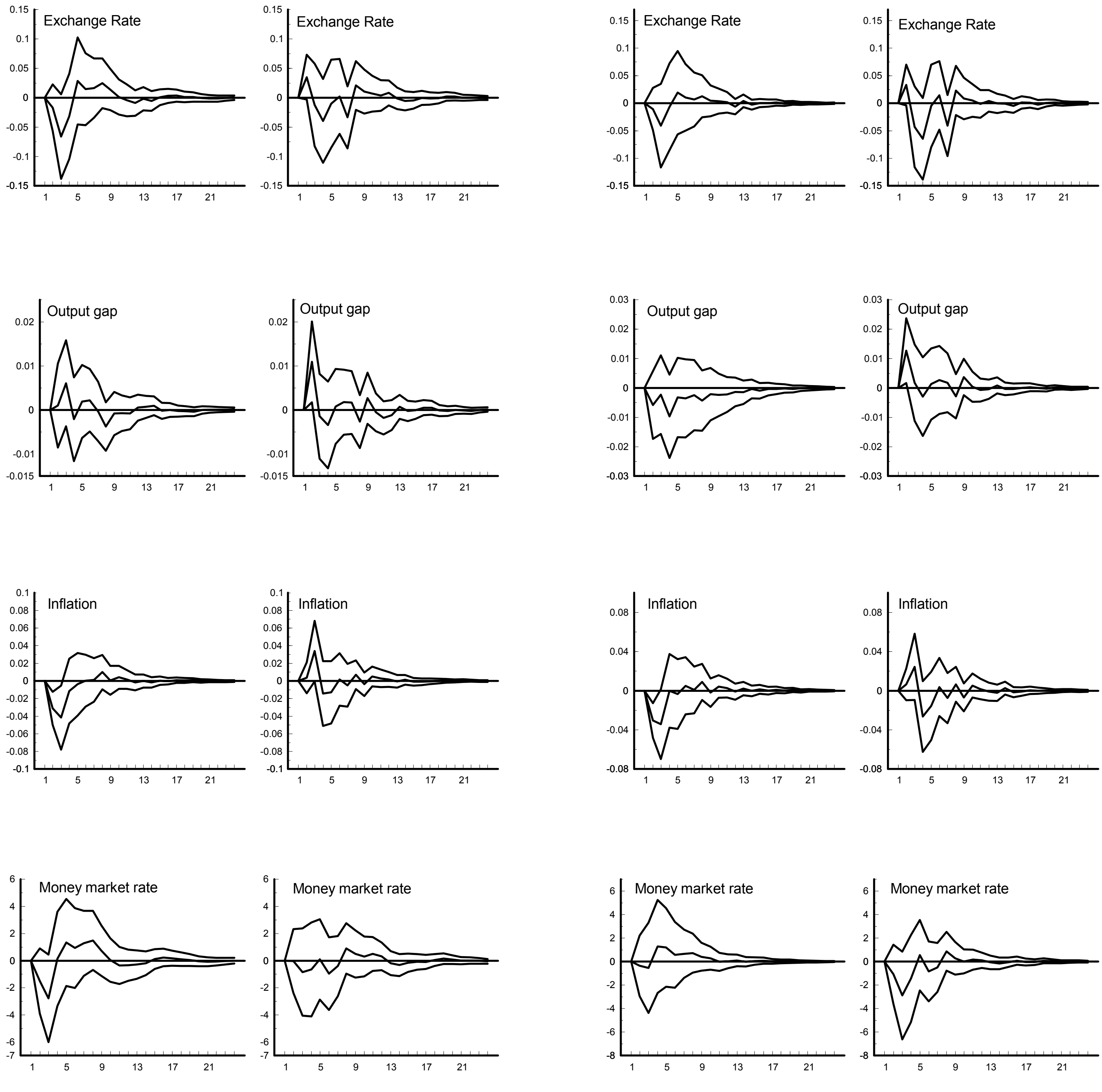
1/ Dashed lines refer to 2 standard-error bands.

Figure 12 (continued)
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Philippines: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/



1/ Dashed lines refer to 2 standard-error bands.

Figure 12 (concluded)
Asymmetric Shocks (Small and Large Values of Inflation Rate)
Turkey: Response to One Standard Deviation Innovations in the Base Money Growth Rate 1/



Large Values | Small Values | Large Values | Small Values

HP Filter | Quadratic Trend Filter

1/ Dashed lines refer to 2 standard-error bands.

Table 1
Block Exogeneity Test Results

Country		H_0: exclude discount rate (HP filter)	H_0: exclude discount rate (QT filter)	H_0: exclude base money growth rate (HP filter)	H_0: exclude base money growth rate (QT filter)
Malaysia	Test statistic	120.4	123.5	240.7	242.8
	Degrees of freedom	12	12	12	12
	No of lags	3	3	3	3
Korea	Test statistic	84.1	83.3	160.0	156.6
	Degrees of freedom	12	12	12	12
	No of lags	3	3	3	3
Philippines	Test statistic	18.0	20.9	115.8	122.3
	Degrees of freedom	16	16	16	16
	No of lags	4	4	4	4
Turkey	Test statistic	3.9	10.3	135.1	142.3
	Degrees of freedom	12	12	12	12
	No of lags	3	3	3	3

Note: Block exogeneity test is based on a likelihood ratio statistic defined as

$$(T\text{-}c)\ (\log|\Sigma_r| - \log|\Sigma_u|)$$

where
$|\Sigma_r|$ = determinant of the restricted residual covariance matrix (obtained by estimating the "core" VAR, as defined in the text)
$|\Sigma_u|$ = determinant of the unrestricted residual covariance matrix (obtained by estimating the "extended" VAR, as defined in the text)
T = number of observations
c = number of the parameters estimated in each equation of the unrestricted system.

This statistic has a chi-squared distribution with degrees of freedom equal to the number of restrictions in the system. If the test result is smaller than the critical level, then we fail to reject the restricted hypothesis (that is, we accept the exclusion of the additional variable).

Table A1
Unit Root Test Statistics

Country	Variable	Augmented Dickey-Fuller Test		Phillips-Perron Test
		Number of lags	Test statistics	
Korea	Inflation	0	-5.316***	-5.316***
	Exchange rate	3	-4.915***	-7.401***
	Output gap (HP trend)	4	-6.083***	-4.571***
	Output gap (Quadratic trend)	2	-3.658***	-3.252**
	Money market rate	1	-3.401**	-2.363
	Discount rate	1	-5.148***	-3.888***
	Base money growth rate	0	-11.293***	-11.293***
Malaysia	Inflation	0	-9.703***	-9.703***
	Exchange rate	2	-3.124**	-6.170***
	Output gap (HP trend)	4	-5.544***	-5.206***
	Output gap (Quadratic trend)	4	0.772	-6.804***
	Money market rate	2	-2.339	-3.676***
	Discount rate	1	-2.598*	-1.942
	Base money growth rate	0	-7.801***	-7.801***
Philippines	Inflation	3	-4.736***	-4.250***
	Exchange rate	0	-6.314***	-6.314***
	Output gap (HP trend)	2	-5.128***	-5.255***
	Output gap (Quadratic trend)	0	-3.514***	-3.514***
	Money market rate	1	-2.156	-1.697
	Discount rate	0	-2.863*	-2.863*
	Base money growth rate	0	-8.996***	-8.996***
Turkey	Inflation	1	-4.328***	-6.605***
	Exchange rate	0	-8.013***	-8.013***
	Output gap (HP trend)	4	-4.680***	-8.988***
	Output gap (Quadratic trend)	4	-2.309	-4.457***
	Money market rate	1	-4.601***	-4.074***
	Discount rate	0	-2.190	-2.190
	Base money growth rate	0	-10.973***	-10.973***

Note: Estimation period begins in 1978:1 and ends in 1999:4 for the Philippines and Turkey. The period starts in 1981:1 and ends in 1999:4 for Korea. The period starts in 1978:1 and ends in 1997:2 for Malaysia. *, **, and *** denotes rejection of the null hypothesis of a unit root at 10%, 5%, and 1% significance level. The critical values are from MacKinnon (1991).