A BRAVE EXERCISE IN MEASURING THE EFFECTS OF G-3 EXCHANGE RATE VOLATILITY ON SMALL OPEN ECONOMIES IN EASTERN EUROPE AND EAST ASIA

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Abstract

I present empirical evidence that exchange rate volatility among the G-3 currencies (dollar, euro, yen) affects small open economies around the globe. In particular, the empirical analysis is applied to the small transitional economies of Eastern Europe, where the dollar competes with the euro, and to the small East Asian economies, which lie on the fault line between the dollar and the yen. I use simple statistical tests to show that the choice of a major currency as an exchange rate anchor matters for the volatility of domestic prices and output. Furthermore, I use a theoretical model as well as a small-scale vector autoregression (VAR) model to show that G-3 exchange rate volatility significantly affects business cycles in Eastern Europe and East Asia.

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1. Introduction

The Bretton Woods system of fixed exchange rates ended in the early 1970s. In the past three decades, the world's major currencies have fluctuated widely against one another. Figure 1 plots the relative values of the world's three major currencies – dollar, euro, yen.[2] These are also known as the Group of Three (or G-3) currencies. Given that the US, the Euro Area, and Japan are large and closed economies, they are fairly immune to sharp fluctuations in the external values of their monies.

In contrast, in smaller countries the exchange rate is probably the single most important price in the entire economy. Many small open economies have chosen to peg their exchange rates to one of the major currencies, usually the one which dominates their trade and financial flows. By pegging to a single currency, small economies with a diversified pattern of trade (in both real goods and financial assets) expose themselves to fluctuations against the other major currencies. If you peg to the dollar, for example, you are floating freely against the yen and the euro. One can think of this as a negative externality problem – the volatility of exchange rates among the major currencies affects small open economies similarly to the way the smoke-spewing factory chimney affects nearby farmers, in the classical textbook example.

This paper will show that G-3 currency volatility does affect significantly business cycles in small open economies around the globe. In particular, I will focus on the small economies in East Asia, which lie on the fault line between the dollar and the yen, and on the three Baltic countries in Eastern Europe, where the dollar competes with the euro. The Baltic states, in particular, constitute probably the best natural experiment the world offers on this topic.

In this paper I present evidence that the euro-dollar exchange rate is one of the important external shocks hitting the three Baltic states, all of whom have chosen hard pegs for their currencies. Furthermore, I extend evidence by other authors about the importance of the yen-dollar rate for business cycles in small East Asian economies, many of whom have maintained pegs to the US dollar over the past twenty years, with the exception of the turbulent period surrounding the 1997 crisis.

How does G-3 exchange rate instability generate domestic volatility in a small open economy, whose currency is pegged to one of the three major currencies? Four channels have been identified. First, there is the "competitiveness" channel: if you peg to a weakening currency, that will lower the relative price of your exports. Figure 2 illustrates the operation of this channel for East Asia (defined as Hong Kong, Korea, Singapore, Taiwan, Indonesia, Malaysia, the Philippines, and Thailand).

[2] Before 1999, the euro-dollar exchange rate was spliced with the DEM-dollar rate.

During the period 1980-2001, a strengthening of the yen against the dollar (note the inverted scale in the figure) clearly correlates with an upturn in exports by East Asian countries, who were keying on the dollar.

Second, there is the "foreign direct investment" channel: if you peg to a weakening currency, incoming FDI might increase, because your country now offers lower production costs. Figure 3 illustrates this – a stronger yen correlates with upturns in FDI flows from Japan to East Asia. Third, there is the "cost of inputs" channel: if you peg to a weakening currency, this translates into higher prices for imported inputs and lower profits for domestic producers. Finally, there is the "cost of borrowing" channel: for an East Asian country, a yen depreciation eases the burden of servicing any yen-denominated debt by reducing the *ex post* real rate of interest.

Note that the four channels pull in opposite directions: the first two channels make depreciations expansionary, while the last two channels have a contractionary effect. The net effect is ambiguous. However, the empirical evidence presented below establishes clearly that the first two channels dominate, and depreciations tend to have an expansionary cyclical effect on domestic output.

Section 2 reviews the literature on the role of external shocks in driving business cycles in East Asia and Eastern Europe. In Section 3, I apply some basic statistical tests to data from the Baltic countries to show that a country's choice of an anchor currency for exchange rate matters for the volatility in domestic inflation and output. Section 4 builds a dynamic sticky-price macro model of a small open economy in order to illustrate the impact of G-3 exchange rate volatility on the domestic business cycle. In Section 5, I estimate a recursive VAR model of a small open economy buffeted by three external shocks: in world interest rates, major currency exchange rates, and the external terms of trade. Impulse response functions for countries in East Asia and the Baltics generally establish that pegging to a weakening currency has an expansionary effect on output. There is a direct link between the impulse response functions estimated here, and the ones derived by numerical simulations in Section 4. Section 6 concludes.

2. Literature review

In reviewing the literature on business cycle fluctuations in emerging East Asia, it is clear that by now no stone has been left unturned in search of an explanation for the spectacular macroeconomic collapse of several emerging economies in 1997. One popular theory maintains that

the crisis was precipitated by volatility in the yen-dollar exchange rate (see Figure 1), coupled with the soft pegs to the US dollar practiced by most countries in the region prior to the crisis. A dollar peg meant that East Asian economies floated freely against the Japanese yen. Given the yen's regional importance, that led to increased macroeconomic instability. The sharp depreciation of the yen against the dollar after mid-1995 was particularly disruptive for the region, and is alleged to have triggered the crisis.

There is broad agreement among economists on the *positive* issue: yen-dollar exchange rate volatility does affect the region. Kwan (2001) and McKinnon and Schnabl (2003) present simple econometric evidence establishing that the yen-dollar exchange rate is a significant driver of business cycles in the region. This paper builds upon their work by analyzing the issue in a VAR framework. Many authors – Ito, Ogawa, and Sasaki (1998), Williamson (2000), Kwan (2001), Kawai (2002), among others – have argued that the right lesson to draw from the 1997 crisis is that exchange rate policies in East Asia had focused too much on the dollar before the crisis. Instead, these authors have argued for greater flexibility in dollar exchange rates and for greater emphasis on the Japanese yen. In particular, some have recommended that East Asian economies stabilize their currencies relative to a basket in which the dollar and the yen are weighted about equally, according to their relative importance in trade flows between East Asia and the rest of the world.

Turning to Eastern and Central Europe, according to a quip in Buiter and Grafe (2002), "identifying and measuring the shocks perturbing the accession countries in the past is an exercise undertaken only by the brave." Samples are too short; data are either missing or of suspect quality. By definition, these "economies in transition" have been hit by tremendous shocks and have experienced large structural changes. Nevertheless, in the past several years we have witnessed the emergence of a small but growing body of empirical work analyzing business cycles in the region. Benczur and Ratfai (2005) presents the basic statistical facts of economic fluctuations in twelve ECE countries over 1993-2004, with a particular focus on the cyclical behavior of the most important macro variables.[3] Elbourne and de Haan (2006) is another comprehensive study of ten ECE countries where the focus is on the transmission of domestic monetary policy shocks and the role played by financial structure. It is important to note that the authors limit their samples in order to ensure that

[3] In addition to the eight new EU member states and the remaining two accession candidates Bulgaria and Romania, the paper includes Russia and Croatia.

they are dealing with a single monetary policy regime in each country; in other words, there are no structural breaks in the data due to institutional changes in monetary policy.

The comprehensive approach to the region is still the exception rather than the rule. Most other papers focus on a subset of countries – the Czech Republic, Hungary, and Poland (CHP) have been particularly well studied, perhaps because they are the largest economies in the region. Mackowiak (2005) studies how much of the variation in prices and output in those three countries can be accounted for by external shocks over the period 1992-2004, and finds that foreign (Euro Area) interest rates are particularly important.[4] Similarly to Mackowiak (2005), I also try to measure the relative importance of exogenous shocks, although the vector of shocks considered in this paper is somewhat different from the one in Mackowiak (2005). There are upsides and downsides to the relatively long time span (thirteen years) analyzed in that paper. On the upside, it provides a generous number of degrees of freedom, a blessing for researchers of ECE business cycles. On the downside, over this time span all three countries changed their monetary-cum-exchange-rate regimes several times. The impact of external shocks on domestic prices and output depends on the monetary policy framework in place. Thus, it is likely that the long samples contain structural breaks. In contrast, I will focus on the three Baltic countries, since these are the only countries in the region who have maintained a single transparent exchange rate regime for an extended period of time. Dibooglu and Kutan (2005) and Golinelli and Rovelli (2002, 2005) are other recent empirical studies of the impact of shocks (both external and domestic) on prices and output in the Czech Republic, Hungary, and Poland.

Finally, there is a sizeable literature applying the optimal currency area (OCA) criteria to the ECE countries in order to determine whether these countries make good candidates for the Euro Area. Recent papers include Korhonen (2003), Fidrmuc and Korhonen (2003, 2004), and Horvath and Ratfai (2004). These papers look at correlations in prices and real economic activity between ECE countries and current members of the Euro Area.

3. Some basic statistical tests

As a first pass at the data, this section looks at simple summary statistics on the volatility of inflation and real GDP growth for the three Baltic states. Estonia, Latvia, and Lithuania are an

[4] Interestingly, Euro Area interest rate shocks have a stronger impact on the ECE countries than on Germany. Jones and Kutan (2004) confirm this result for the case of Hungary.

excellent natural experiment on the effects of G-3 exchange rate instability on small open economies with pegged currencies. The three are very similar in terms of population, economic size, level of economic development, and sectoral composition of output (see Table 1). The three countries share a broadly similar direction of trade and are equally vulnerable to certain types of external shocks – for example, Russia's default and devaluation in 1998 caused an across-the-board recession in the region. All three joined the European Union in May 2004, and are gearing up to join the Euro Area at the earliest feasible date.

This background of similarities helps bring into sharp relief one important difference. Each country maintained a *different* fixed exchange rate regime for an extended period of time. Estonia has been on a currency board with the German mark (and now the euro) since June 1992. Between April 1994 and February 2002, Lithuania was on a currency board with the US dollar. Lithuania's choice was motivated by the extensive dollarization of the country's financial system, as well as by the importance of dollar-invoiced imports of crude oil for the country which has the region's only major oil refinery. Finally, Between February 1994 and January 2005, Latvia opted for a conventional peg, rather than a currency board, to the SDR, the IMF-maintained basket of currencies.[5] Latvia's exchange rate with the SDR never budged from the initial level. Furthermore, the Latvian central bank usually backed the monetary base at least 100% with foreign reserves, thus making the country's peg a *quasi*-currency board arrangement.[6]

All data come from IMF's International Financial Statistics. I use monthly PPI data (in log-differences) to measure inflation. Relative to the CPI, the PPI contains a lower fraction of services and a higher fraction of internationally traded goods. Thus, it is not driven as strongly by Balassa-Samuelson dynamics as the CPI. I also use quarterly GDP data (at constant prices) to measure GDP growth. To produce series free of seasonal fluctuations, I take the fourth difference of the (logged) series.

Table 2 shows summary statistics on monthly PPI inflation in the Baltic countries for a common sample beginning in 1995 and ending in 2001. I choose to start in 1995 – presumably by that time, the price levels in all three countries were securely anchored by their newly-adopted exchange rate regimes. To get an idea about units of measurement, Estonia's average inflation is

[5] The current (July 2006) composition of the SDR is 43% US dollars, 35% euros, 11% Japanese yen, and 11% British pounds.

[6] de Haan, Berger, and Fraassen (2001) offers a good summary of the currency arrangements in the three Baltic countries. Note that in preparation for accession to the Euro Area, Lithuania re-pegged to the euro in February 2002, while Latvia did the same in January 2005.

approximately 0.5% per month, or about 6% *per annum*. Latvia's PPI inflation rate has been less volatile, with a lower standard deviation, than either Estonia's or Lithuania's. An F-test reveals that both differences are highly statistically significant (with *p*-values of less than 0.01).

A possible criticism here is that inflation in all three countries was systematically declining over time, and the results reported above could be tainted by the trend in the data.[7] As a robustness check, I regressed each time series (logged and fourth-differenced) on a constant and a linear time trend. Then I looked at the volatility of the residuals from these three regressions. The results (not reported here) were almost identical to those in Table 2.

Table 3 shows summary statistics on quarterly GDP growth in the Baltics over the period 1995-2001. Estonia's average quarterly GDP growth rate of 1.23% implies an annual growth rate of about 5%. Once again, quarterly volatility in Latvia's GDP growth rate has been lower than in the other two countries. However, given the small sample size, only the difference between Latvia and Lithuania is marginally significant (*p*-value = 0.0573).

From these two tables, whether a country pegs to the euro, the dollar, or a basket dominated by the two currencies appears to matter for inflation and output volatility. While the simple summary statistics presented here are suggestive, one should not overstate their authority. Correlation is not causation, and volatility among the major currencies is just one of the external shocks buffeting small open economies. In the next two sections of the paper, I refine the analysis by sketching out a theoretical model and by estimating a VAR. Both models are intended to flesh out the dynamic effects of exchange rate volatility among the world's major currencies on small open economies.

4. A theoretical model

In this section, I sketch out a dynamic sticky-price macro model of a small open economy trading with two large countries. The exchange rate between the two is the model's only source of uncertainty. The small economy has to decide which currency or currency basket to peg to. The model moves past the time-honored question of whether the exchange rate should be fixed or floating.[8] Calvo and Reinhart (2002) have noted the pervasive "fear of floating" in emerging economies. Governments in these countries overwhelmingly choose to stabilize the exchange rate, in order to deal with liability dollarization, maintain competitiveness, provide the economy with a

[7] I thank Patricia Dillon for bringing up this point.
[8] To quote Buiter and Grafe (2002): "Anchor, float, or abandon ship?"

nominal anchor, and provide the private sector with an informal hedge against payments risk. Consequently, the model tackles the question "anchor to what?" The fully-specified model is available in Slavov (2005). Here, I only sketch out the setup and the results. There is a direct link between the impulse response functions simulated numerically here (Figures 5 thru 7), and the ones estimated using the VAR model of Section 5 (Figures 8 and 9).

In the model, there are three regions in the world: two large economies A and B, and a small open economy (which I will refer to as "Home"). One should think of A and B not as countries but as currency areas – a "dollar area" and a "euro area" – in the sense that either the dollar or the euro is the dominant currency for pricing trade flows. Think of Home as one of the three Baltic countries. The small open economy produces a couple of goods which get exported to A and B, respectively. Neither is consumed domestically. Domestically-owned retailers import a good from A and another good from B. They combine, differentiate, and re-sell imports to domestic households and to entrepreneurs. Households consume imports (and imports only), supply labor, and own retailers and export-producing firms. Entrepreneurs consume some imports and sell the rest to exporting firms, which use them as productive capital. Exporting firms produce goods out of labor and capital, and export all output to A or B. Figure 4 summarizes the flow of goods in the small open economy.

The *only* source of uncertainty in the model is the euro-dollar exchange rate. There are no other sources of uncertainty in the model. In particular, there are no domestic nominal shocks. Therefore, unlike in most small open economy models, domestic monetary control is not at issue here.

The model has the features necessary to generate both the expansionary and contractionary aspects of exchange rate depreciations. The expansionary side of depreciations comes from the *mercantile* effect they have on domestic exports, output, and consumption. The contractionary side of depreciations is due to higher domestic prices of imports and due to volatility-enhancing balance sheet effects on capital investment and future output. These features can be traced back to the transmission channels identified in the introduction to this paper.

All the action in the model is generated by instability in the euro-dollar exchange rate, combined with financial market incompleteness and imperfect pass-through to the domestic price level. One can think of imperfect pass-through as a form of price stickiness, which is addressed by monetary policy in the model below.

4.1 Households, retailers, exporting firms, government

In Home, there are households, retailers, exporting firms, a government, and entrepreneurs. I discuss each sector in turn. Households consume and supply labor to firms. They do not have access to financial markets and must spend all of their labor and dividend income (from retailers) within the current period. The household's allocation problem is a static one. They play a passive role in this model – that is why the household sector is modeled as simply as possible. Typically, other authors have assumed that households either have access to complete financial markets or are completely shut off from them (as is the case here). The latter assumption is more tractable and perhaps more realistic – credit constraints on the household sector have been shown to be an important driver of aggregate consumption dynamics. The same assumption is employed in Krugman (1999), Cespedes, Chang, and Velasco (2000), and Devereux and Lane (2003).

Retailers are monopolistically competitive and are owned by the households. They purchase imports from both countries A and B and assemble them costlessly to produce a brand of the consumption good. In modeling retailers' price-setting decisions, I follow the tradition of Calvo (1983) and Yun (1996). Retailers update their prices infrequently. Independently of past history, each period only a fraction of them gets a chance to adjust prices. Due to the law of large numbers, there is no aggregate uncertainty or income uncertainty for the representative household. Sticky prices generate imperfect exchange rate pass-through which is crucial in generating the model's results. If pass-through were instantaneously unity, the impact of shocks to the euro-dollar exchange rate on Home would have been *completely independent* of the exchange rate regime. In other words, the exchange rate regime would have been irrelevant at the macroeconomic level.[9]

Exporting firms purchase labor from households and capital from entrepreneurs in order to produce their export good, which then goes to either country A or country B. I assume that capital depreciates completely each period. Domestic firms are competitive price-takers in world markets.

The government's only role in this model is to set the two domestic exchange rates, toward the dollar and toward the euro, as functions of the euro-dollar exchange rate. I allow for a continuum of exchange rate regimes which includes single-currency pegs as special cases, and can be generalized as a peg to a basket which contains the dollar and the euro. So one can think of Estonia's euro peg and Lithuania's dollar peg (until February 2002) as special cases, with all the weight being placed on a single currency. One can think of the SDR peg practiced by Latvia between February

[9] This is just a special case of nominal neutrality when prices are completely flexible.

1994 and January 2005 as a peg to a basket in which the dollar and the euro were weighted about equally (see footnote 7).

Again, the set of monetary regimes considered by the model is restricted to a continuum of exchange rate pegs. It does not consider inflation-targeting or targeting short-term nominal interest rates or targeting the money supply. The large literature on "fear of floating" started by Calvo and Reinhart (2002) has demonstrated persuasively that the monetary authorities in emerging markets tend to focus on the exchange rate as their preferred tool for conducting monetary policy.

4.2 Entrepreneurs

Entrepreneurs play a crucial role in the model. They purchase the index consumption good and re-sell it to firms. Firms use it as capital in producing exports. Capital purchases are financed by entrepreneurs' net worth and by their borrowing in A's currency (US dollars). Entrepreneurs cannot borrow in the domestic currency and are forced to take on unhedged foreign currency debt. This form of market incompleteness was dubbed "original sin" by Eichengreen and Hausmann (1999). Dollar borrowing is an institutional constraint on the model. It is meant to capture the role of the dollar as "international money," especially in international capital flows.

The setup of the entrepreneurial sector is standard in the literature started by Bernanke, Gertler, and Gilchrist (1998). At the end of each period, entrepreneurs combine their net worth with dollar-denominated borrowing to finance purchases of imports which will be used in *next* period's production of exports by firms. There is an interest rate premium on dollar debt, which is increasing in entrepreneurial leverage. At the beginning of each period, after observing the realization of the shock to the euro-dollar exchange rate, entrepreneurs receive payments from firms for the services of capital that entrepreneurs secured for them at the end of last period. They also repay the dollar debt they incurred back then. Finally, they consume a fraction of their net income. Entrepreneurs are assumed to be risk-neutral.

4.3 Numerical simulations of euro-dollar exchange rate shocks

Next, I solve the model by using standard linear approximation techniques (details in Slavov (2005)), and I simulate the model numerically. The time unit of the model is one quarter, which matches the data frequency of the VAR model in Section 5. Now suppose that the euro depreciates against the dollar by 10%. The shock is temporary and gradually fades away. Figures 5 through 7

describe the response of the system to this shock under three alternative exchange rate regimes – a euro peg, a peg to a basket in which the dollar and the euro are weighted equally, and a dollar peg. One can think of these three figures as describing, respectively, Estonia, Latvia (during 1994-2005) and Lithuania (during 1994-2002). Obviously, we will seek to compare these figures to the impulse response functions generated by the VAR model of Section 5 for the Baltic countries (Figure 9). The unit of measurement is percentage deviations from a constant steady state.

Note that a euro depreciation is expansionary under a euro peg and contractionary under a dollar peg (compare Figures 5 and 7). Note also that if we replace "euro" with "yen" in Figure 7, we can reinterpret that figure as describing the small open economies in East Asia which have practiced soft pegs to the US dollar, both before and after the 1997 crisis. Then, we can compare the theoretical Figure 7 to the empirical Figure 8.

5. A VAR model of the impact of G-3 exchange rate volatility on small open economies

In order to sort out empirically the vulnerability of pegging small open economies in East Asia and Eastern Europe to various external shocks, in this section I estimate a small-scale vector autoregression (VAR) model of how output in small open economies is affected by three external shocks: in the world interest rate, the yen-dollar (or euro-dollar, as appropriate) exchange rate, and in the external terms of trade. Commentators of East Asian business cycles have identified these three as either the "three blessings" or the "three curses," depending on the current state of affairs. I work with the three Baltic countries and with the five small East Asian economies for which sufficiently long series of quarterly GDP data are available: Korea, Malaysia, the Philippines, Hong Kong, and Singapore.[10]

5.1. Model setup

Here is the structural form of the model I estimate:

$$A\begin{pmatrix} I_t \\ E_t \\ TOT_t \\ GDP_t \end{pmatrix} = B(L)\begin{pmatrix} I_{t-1} \\ E_{t-1} \\ TOT_{t-1} \\ GDP_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_t^I \\ \varepsilon_t^E \\ \varepsilon_t^{TOT} \\ \varepsilon_t^{GDP} \end{pmatrix} \qquad \textbf{(1)}$$

[10] The IFS does not cover Taiwan. Quarterly GDP series were too short for China, Indonesia, and Thailand.

All data come from IMF's International Financial Statistics and the time frequency is quarterly. I_t is the London inter-bank offered rate (LIBOR). I chose this particular short-term dollar interest rate because it captures worldwide monetary conditions. E_t is the yen-dollar or euro-dollar exchange rate, as appropriate. TOT_t denotes the country-specific terms of trade for Hong Kong, Korea, and Singapore. Due to unavailable data, for Malaysia and the Philippines I instead used the region-wide terms of trade for "Asia," which is defined by the IFS to only include the developing countries in that region. Due to lack of data for the three Baltic countries, I used the external terms of trade for "Europe," which once again is defined to include only the developing countries and countries in transition. [11] For GDP_t, I use quarterly GDP data at constant prices. All variables enter in logs, except for the interest rate. Since many of the variables are non-stationary in levels, I used the Hodrick Prescott (HP) filter to de-trend all variables.[12] Obviously, I will want to compare the impulse response functions generated by the VAR model to the ones from the theoretical model in Section 4 (Figures 5 thru 7), where all variables were measured in percentage deviations from a constant steady state. Finally, in order to deal with seasonal fluctuations, I regressed all HP-filtered series on three seasonal dummies. The residuals from these regressions were then used for the VAR model.

A is a 4x4 lower triangular matrix, with ones on the main diagonal. Due to these restrictions on *A*, the above system is recursive and this imposes a certain causal ordering on the structural model. In particular, the interest rate is only affected by its own contemporaneous innovations. The exchange rate is affected by its own contemporaneous innovations and by contemporaneous innovations in interest rates. On the other extreme, GDP_t is affected by contemporaneous innovations in all four variables. Loosely speaking, the interest rate is the model's most "exogenous" variable, while GDP_t is the most "endogenous" one.

Imposing such a recursive structure is a common way of identifying a VAR model. Any causal ordering is somewhat arbitrary, and there are 4! = 24 different ways of ordering the variables. As a robustness check, in Appendix Figures A10 and A11, I report generalized impulse response functions, as described by Pesaran and Shin (1998), which do not depend on the ordering of the VAR. They are nearly identical to the ones presented and discussed below. Therefore, the model's results do not depend crucially on how the variables are ordered.

[11] As a robustness check, I tried the world price of oil in place of the terms of trade. Results were fairly robust to this modification.

[12] Because of a break in the GDP numbers for Singapore, I could not apply the HP filter. Instead, I fitted a cubic time polynomial to the logged GDP series, and then used the residuals from that regression.

One still must offer a serious discussion of the identification assumptions. It is easiest to justify why GDP_t is at the bottom of the causal ordering. The output of a small open economy is unlikely to affect contemporaneously (or at all) any of the other variables of the model. I place the interest rate above the dollar exchange rate because the former is largely driven by the US Federal Reserve, which treats the external value of the dollar with neglect. In turn, ordering the exchange rate above the terms of trade is consistent with a huge body of empirical evidence over the past 25 years, since Isard (1977), showing that the relative prices of internationally traded goods are dominated in the short run by nominal exchange rate dynamics, due to price stickiness. Obstfeld (2001) offers a compact survey of this literature.

The model's reduced form is:

$$\begin{pmatrix} I_t \\ E_t \\ TOT_t \\ GDP_t \end{pmatrix} = A^{-1}B(L)\begin{pmatrix} I_{t-1} \\ E_{t-1} \\ TOT_{t-1} \\ GDP_{t-1} \end{pmatrix} + A^{-1}\begin{pmatrix} \varepsilon_t^I \\ \varepsilon_t^E \\ \varepsilon_t^{TOT} \\ \varepsilon_t^{GDP} \end{pmatrix} \qquad \textbf{(2)}$$

The inverse matrix A^{-1} will also be lower-triangular with ones on the main diagonal.

In general, the VAR literature recommends parsimony in lag selection. I also face a shortage of degrees of freedom: with as little as 31 data points for one of the countries. Therefore, I decided to follow the Schwarz Information Criterion (SIC) which imposes a larger penalty for additional coefficients, relative to the also commonly-used Akaike Information Criterion (AIC). The SIC uniformly recommended one lag for all countries. The model was estimated using EViews 5.1.

Before presenting the results, a word of caution is in order. In the apt words of Stock and Watson (2001), there are four tasks macro-econometricians perform: data description, forecasting, structural inference, and policy evaluation. VARs have proven to be powerful and reliable tools only for the first two tasks. VARs are useful in searching for worthwhile hypotheses, and in uncovering restrictions (strong correlations in the data) which a theoretical model should then target to explain and match. Thus, the VAR model is intended to go hand in hand with the theoretical model developed in the previous section.

5.2 Results

For all eight countries, I restricted the samples appropriately, in order to ensure that each country maintained a single monetary policy regime, in particular, a fixed exchange rate to the US

dollar, the euro, or the SDR. In addition to anecdotal evidence, I also consulted the extensive country chronologies in Reinhart and Rogoff (2004). Individual country samples are discussed below.

In the case of South Korea, the sample starts in Q2 of 1980 and ends in Q2 of 1997, right before the outbreak of the East Asian crisis. For the Philippines, I chose to start in Q2 of 1985, because the country's currency was just coming out of a free fall. Once again, the sample ends in Q2 of 1997. Neither country came back to quite the same exchange rate regime after the crisis subsided. Hong Kong's sample runs continuously from Q1 of 1984, right after the country adopted a currency board arrangement with the US dollar, and until Q1 of 2006.

Next, in the cases of Malaysia and Singapore, the samples start in Q2 of 1988 and in Q4 of 1984 due to data availability. For Malaysia, the sample ends in Q2 of 2005, right before the country abandoned its hard peg to the US dollar in July 2005, together with China. The Malaysian sample thus includes the years of soft unofficial pegging to the dollar before 1997, the period of turbulence in 1997-98, and the post-crisis period of following a hard dollar peg. To deal with the obvious structural break in the Malaysia VAR, I add a dummy variable for the East Asian crisis, which is set to unity for the period between Q3:1997 and Q3:1998.[13] The same crisis dummy is also used in the Singapore VAR, since there is some evidence of a break in Singapore's exchange rate policies during the crisis.

Turning to the three Baltic countries, Estonia's sample starts in Q2 of 1993, due to data availability. For Latvia and Lithuania, I choose to start in Q2 of 1994. Latvia pegged to the SDR in February 1994, while Lithuania pegged to the dollar in early April 1994. The Latvian sample ends in Q4 of 2004, right before the country re-pegged to the euro. For similar reasons the Lithuanian sample ends in Q4 of 2001.

Next, I present the results from standard innovation accounting exercises. Figures 8 and 9 presents the impulse response functions of output to a one-standard-deviation shock to the yen-dollar or euro-dollar exchange rate, as appropriate. For all five East Asian countries, an innovation to the yen-dollar exchange rate has a negative effect on real output. The impulse response functions are hump-shaped and the impact of the shock on output peaks after anywhere between 2 and 6 quarters in different countries. In two out of the five cases, the effect is statistically significant (each line has a band of ±2 standard deviations).[14] In the other three cases, the results are *very* close to being significant. Pegging to a strengthening currency (the dollar, in this case) is associated with an output

[13] Brada and Kutan (1999) is another paper which adopts the same approach in order to deal with structural breaks such as currency and financial crises, administrative price changes, and major changes to tax laws.
[14] Analytic standard errors were used in computing the bands.

contraction. This matches the dynamics from the theoretical model (see Figure 7 where one should think of the yen, rather than the euro, depreciating against the dollar).

Turning to the three Baltic states, an innovation in the orthogonal error hitting the euro-dollar exchange rate turns out to have a positive effect on Estonia's GDP: pegging to a weakening major currency (the euro) tends to cause a cyclical upturn in output. The effect is statistically significant, just barely. A euro depreciation also has a positive effect on Latvia, which was pegged to the SDR, a basket dominated by the dollar and the euro. However, this effect is *not* statistically significant, again just barely. Finally, a euro depreciation has a negative effect, on impact, on the dollar-pegging country, Lithuania. However, this result is not statistically significant.

These results are once again broadly consistent with the model of Section 4, which predicted a positive effect on Estonia (Figure 5), a negative effect on Lithuania (Figure 7), and no particular effect on Latvia (Figure 6).

Table 4 offers a perspective on the overall fit of the model by presenting variance decompositions of output for the eight countries. The three external shocks of the model explain a relatively high percentage of the forecasting error variance of real output for Hong Kong, Korea, the Philippines, Latvia, and Lithuania. The exchange rate shock does very well in explaining output variation in the two East Asian city states: Hong Kong and Singapore. Note also that in six out of the eight countries, G-3 exchange rate volatility accounts for a percentage of domestic output fluctuations which is above or comparable to the percentage accounted for by interest rate volatility. The two exceptions are Korea and the Philippines, where interest rate volatility accounts for about 20% of domestic output fluctuations, a number compatible with the estimates of Uribe and Yue (2003).

6. Conclusion

This paper presents empirical evidence that G-3 exchange rate volatility affects pegging small open economies in East Asia and Eastern Europe. I use simple statistical tests to show that the choice of an exchange rate anchor matters for the volatility of prices and output. Furthermore, I build a theoretical model and a small-scale VAR to show that G-3 exchange rate volatility affects business cycles in Eastern Europe and East Asia. A final interesting result is that G-3 exchange rate volatility is at least as important a disturbance for domestic output in many of these countries as volatility in the world interest rate.

REFERENCES

Benczur, Peter, and Attila Ratfai. Economic Fluctuations in Central and Eastern Europe: The Facts. Discussion Paper 4846, CEPR, 2005.

Bernanke, Ben, Mark Gertler, and Simon Gilchrist. The financial accelerator in a quantitative business cycle framework. Working Paper 6455, National Bureau of Economic Research, March 1998.

Brada, Josef, and Ali Kutan. The end of moderate inflation in three transition economies? Working Paper 1999-003, Federal Reserve Bank of St. Louis, 1999.

Buiter, Willem H., and Clemens Grafe. "Anchor, float, or abandon ship: exchange rate regimes for the accession countries." Banca Nazionale del Lavoro Quarterly Review 55 (2002): 111-142.

Calvo, Guillermo A. "Staggered prices in a utility-maximizing framework." Journal of Monetary Economics 12 (1983): 383-398.

Calvo, Guillermo A., and Carmen M. Reinhart. "Fear of floating." Quarterly Journal of Economics 117 (2002): 379-408.

Cespedes, Luis, Roberto Chang, and Andres Velasco. Balance sheets and exchange rate policy. Working Paper 7840, National Bureau of Economic Research, August 2000.

Dibooglu, Sel, and Ali Kutan. "Sources of Inflation and Output Movements in Poland and Hungary: Policy Implications for Accession to the Economic and Monetary Union." Journal of Macroeconomics 27 (2005): 107-31.

Eichengreen, Barry, and Ricardo Hausmann. Exchange rates and financial fragility. Working Paper 7418, National Bureau of Economic Research, November 1999.

Elbourne, Adam, and Jakob de Haan. "Financial structure and monetary policy transmission in transition countries." Journal of Comparative Economics 34 (2006): 1-23.

Fidrmuc, Jarko, and Iikka Korhonen. "Similarity of Supply and Demand Shocks between the Euro Area and the CEECs." Economic Systems 27 (2003): 313-34.

Fidrmuc, Jarko, and Iikka Korhonen. "The Euro Goes East: Implications of the 2000-2002 Economic Slowdown for Synchronisation of Business Cycles between the Euro Area and CEECs." Comparative Economic Studies 46 (2004): 45-62.

Gali, Jordi, and Tommaso Monacelli. Monetary policy and exchange rate volatility in a small open economy. Working Paper 8905, National Bureau of Economic Research, April 2002.

Golinelli, Roberto, and Riccardo Rovelli. “Painless Disinflation? Monetary Policy Rules in Hungary, 1991-99.” Economics of Transition 10 (2002): 55-91.

Golinelli, Roberto, and Riccardo Rovelli. “Monetary Policy Transmission, Interest Rate Rules and Inflation Targeting in Three Transition Countries.” Journal of Banking and Finance 29 (2005): 183-201.

de Haan, Jakob, Helge Berger, and Erik van Fraassen. “How to Reduce Inflation: An Independent Central Bank or a Currency Board? The Experience of the Baltic Countries.” Emerging Markets Review 2 (2001): 218-43.

Horvath, Julius, and Attila Ratfai. ”Supply and Demand Shocks in Accession Countries to the Economic and Monetary Union.” Journal of Comparative Economics 32 (2004): 202-11.

Isard, Peter. “How far can we push ‘the law of one price’?” American Economic Review 67 (1977): 942-948.

Ito, Takatoshi, Eiji Ogawa, and Yuri Nagataki Sasaki. How did the dollar peg fail in Asia? Working Paper 6729, National Bureau of Economic Research, September 1998.

Jones, Garett, and Ali Kutan. “Exchange Rate Management Strategies in the Accession Countries: The Case of Hungary.” Comparative Economic Studies 46 (2004): 23-44.

Kawai, Masahiro. Exchange rate arrangements in East Asia: lessons from the 1997-98 currency crisis. Manuscript, Japanese Ministry of Finance, September 2002.

Korhonen, Iikka. “Some Empirical Tests on the Integration of Economic Activity between the Euro Area and the Accession Countries: A Note.” Economics of Transition 11 (2003): 177-96.

Krugman, Paul. 1999. “Balance sheets, the transfer problem, and financial crises,” in International finance and financial crises: essays in honor of Robert P. Flood, Jr. Assaf Razin and Andrew K. Rose, eds. Norwell, MA: Kluwer Academic Publishers, pp. 31-44.

Kwan, C.H. Yen bloc: toward economic integration in Asia. Washington, DC: Brookings Institution Press, 2001.

Mackowiak, Bartosz. How much of the Macroeconomic Variation in Eastern Europe is Attributable to External Shocks? Discussion Paper 2005-061, Collaborative Research Center 649, Humboldt University, Berlin, 2005.

McKinnon, Ronald, and Gunther Schnabl. “Synchronised Business Cycles in East Asia and Fluctuations in the Yen/Dollar Exchange Rate.” World Economy 26 (2003): 1067-88.

McKinnon, Ronald, and Gunther Schnabl. “The East Asian Dollar Standard, Fear of Floating, and Original Sin.” Review of Development Economics 8 (2004): 331-60.

Obstfeld, Maurice. “International macroeconomics: beyond the Mundell-Fleming model.” IMF Staff Papers 47 (2001, Special Issue): 1-39.

Pesaran, Hashem, and Yongcheol Shin. “Impulse Response Analysis in Linear Multivariate Models.” Economics Letters 58 (1998): 17-29.

Reinhart, Carmen M., and Kenneth S. Rogoff. “The modern history of exchange rate arrangements: a reinterpretation.” Quarterly Journal of Economics 119 (2004): 1-48.

Slavov, Slavi. Should small open economies in East Asia put all their eggs in one basket: the role of balance sheet effects. Working Paper, Department of Economics, Pomona College, December 2005.

Stock, James H., and Mark W. Watson. “Vector autoregressions.“ Journal of Economic Perspectives 15 (2001): 101-115.

Uribe, Martin, and Vivian Yue. Country Spreads and Emerging Countries: Who Drives Whom? Working Paper 10018, National Bureau of Economic Research, October 2003.

Williamson, John. Exchange rate regimes for emerging markets: reviving the intermediate option. Washington, DC: Institute for International Economics, 2000.

Yun, Tack. “Nominal price rigidity, money supply endogeneity, and business cycles.” Journal of Monetary Economics 37 (1996): 345-370.

Table 1: Some basic statistics for the three Baltic countries

	Estonia	Latvia	Lithuania
Population (2006)	1.3 mln.	2.3 mln.	3.6 mln.
GDP (PPP, 2005)	$22.3 bln.	$30.3 bln.	$49.2 bln.
GDP *per capita* (PPP, 2005)	$16,700	$13,200	$13,700
GDP composition by sector (2005): agriculture	4.0%	4.0%	5.5%
industry	29.4%	26.1%	32.5%
services	66.6%	69.9%	62.0%

Source: CIA, The World FactBook 2006

Table 2: Summary statistics on monthly PPI inflation in the Baltics, 1995-2001

	Estonia (€ peg)	Latvia (SDR peg)	Lithuania ($ peg)
Mean (%)	0.54	0.30	0.44
Standard deviation (%)	1.10	0.78	2.03
Observations	84	84	84

Source: IMF, International Financial Statistics

Table 3: Summary statistics on quarterly GDP growth in the Baltics, 1995-2001

	Estonia (€ peg)	Latvia (SDR peg)	Lithuania ($ peg)
Mean (%)	1.23	1.05	0.71
Standard deviation (%)	1.01	0.95	1.38
Observations	28	28	28

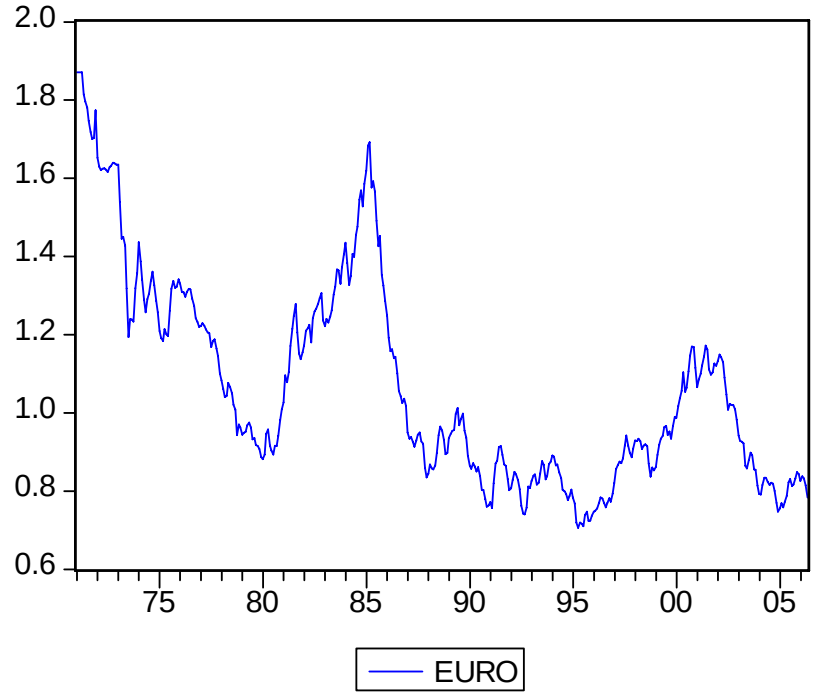
Source: IMF, International Financial Statistics

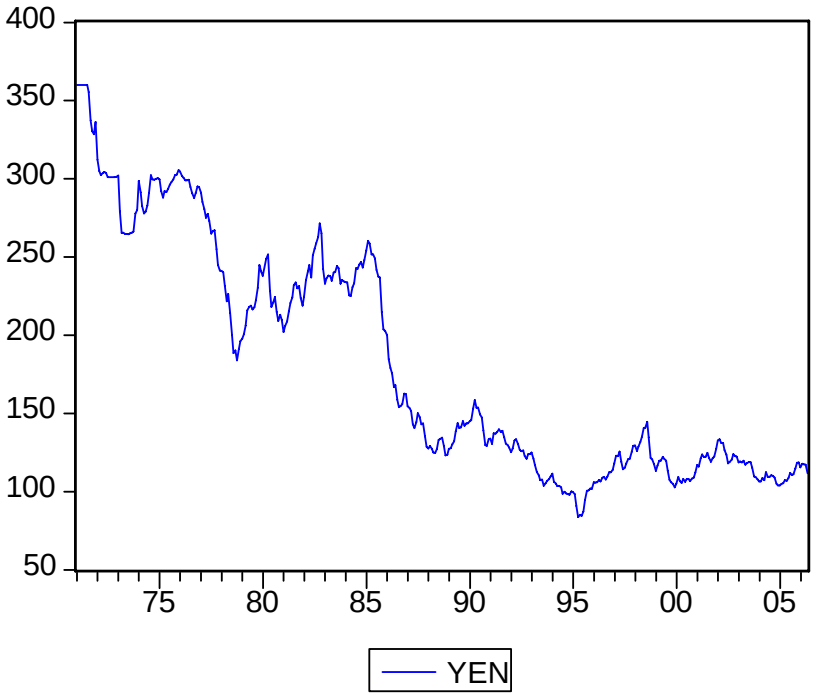
Table 4: Variance decomposition of output (% of *k*-quarter ahead forecasting error variance explained by the three external shocks)

Country	*k* =	4	8	12	16
Korea	**shock to interest rate**	17	17	17	17
	shock to yen-dollar rate	1	3	4	4
	shock to terms of trade	7	7	7	7
	three external shocks combined	**26**	**27**	**28**	**28**
Malaysia	**shock to interest rate**	0	0	0	0
	shock to yen-dollar rate	7	10	10	10
	shock to terms of trade	3	3	4	4
	three external shocks combined	**11**	**14**	**14**	**14**
Philippines	**shock to interest rate**	16	22	22	21
	shock to yen-dollar rate	3	9	12	13
	shock to terms of trade	3	3	3	3
	three external shocks combined	**22**	**34**	**37**	**37**
Hong Kong	**shock to interest rate**	3	5	7	8
	shock to yen-dollar rate	21	32	31	31
	shock to terms of trade	17	15	16	15
	three external shocks combined	**42**	**51**	**53**	**54**
Singapore	**shock to interest rate**	1	1	1	2
	shock to yen-dollar rate	6	19	23	23
	shock to terms of trade	0	0	1	1
	three external shocks combined	**8**	**21**	**25**	**26**
Estonia	**shock to interest rate**	0	0	1	1
	shock to euro-dollar rate	8	8	8	8
	shock to terms of trade	3	3	3	3
	three external shocks combined	**11**	**12**	**12**	**12**
Latvia	**shock to interest rate**	10	11	11	11
	shock to euro-dollar rate	9	9	9	9
	shock to terms of trade	17	17	17	17
	three external shocks combined	**35**	**36**	**37**	**37**
Lithuania	**shock to interest rate**	6	6	6	6
	shock to euro-dollar rate	4	4	4	4
	shock to terms of trade	13	13	13	13
	three external shocks combined	**22**	**23**	**23**	**23**

Note: Numbers might not add up due to rounding.

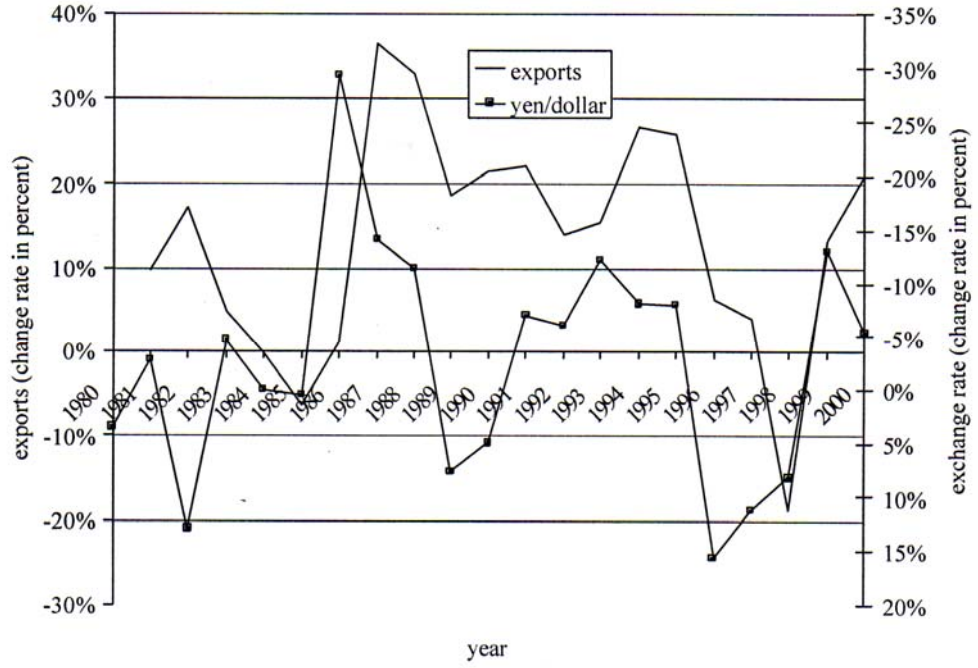
Figure 1: Euro-dollar and yen-dollar exchange rate, January 1971 – May 2006





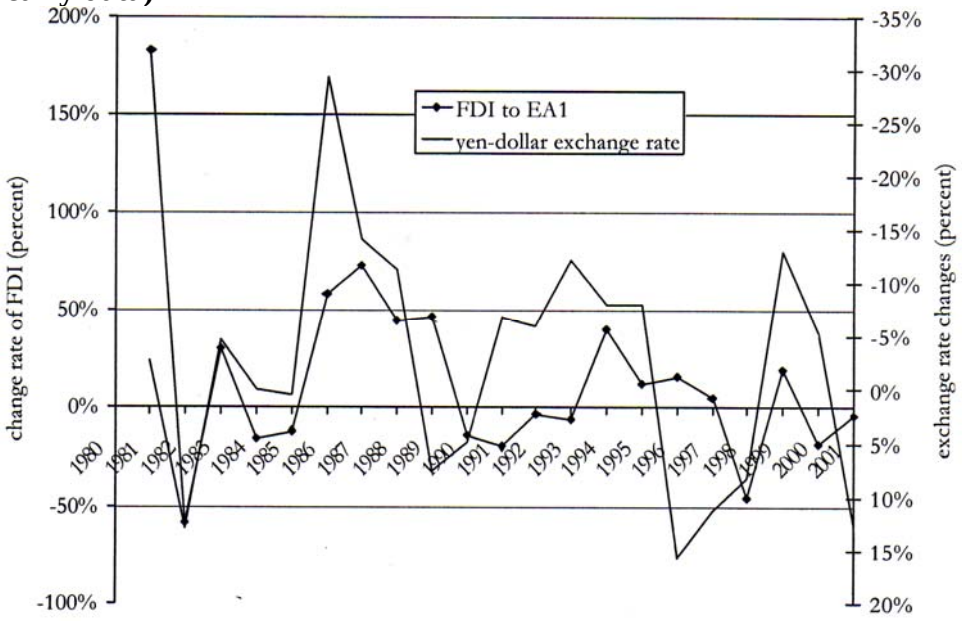
Source: IMF, International Financial Statistics
Note: Before 1999, the euro-dollar exchange rate was spliced with the Deutsche mark-dollar rate.

Figure 2: East Asian exports and the yen-dollar exchange rate, 1980-2001 (yearly data)



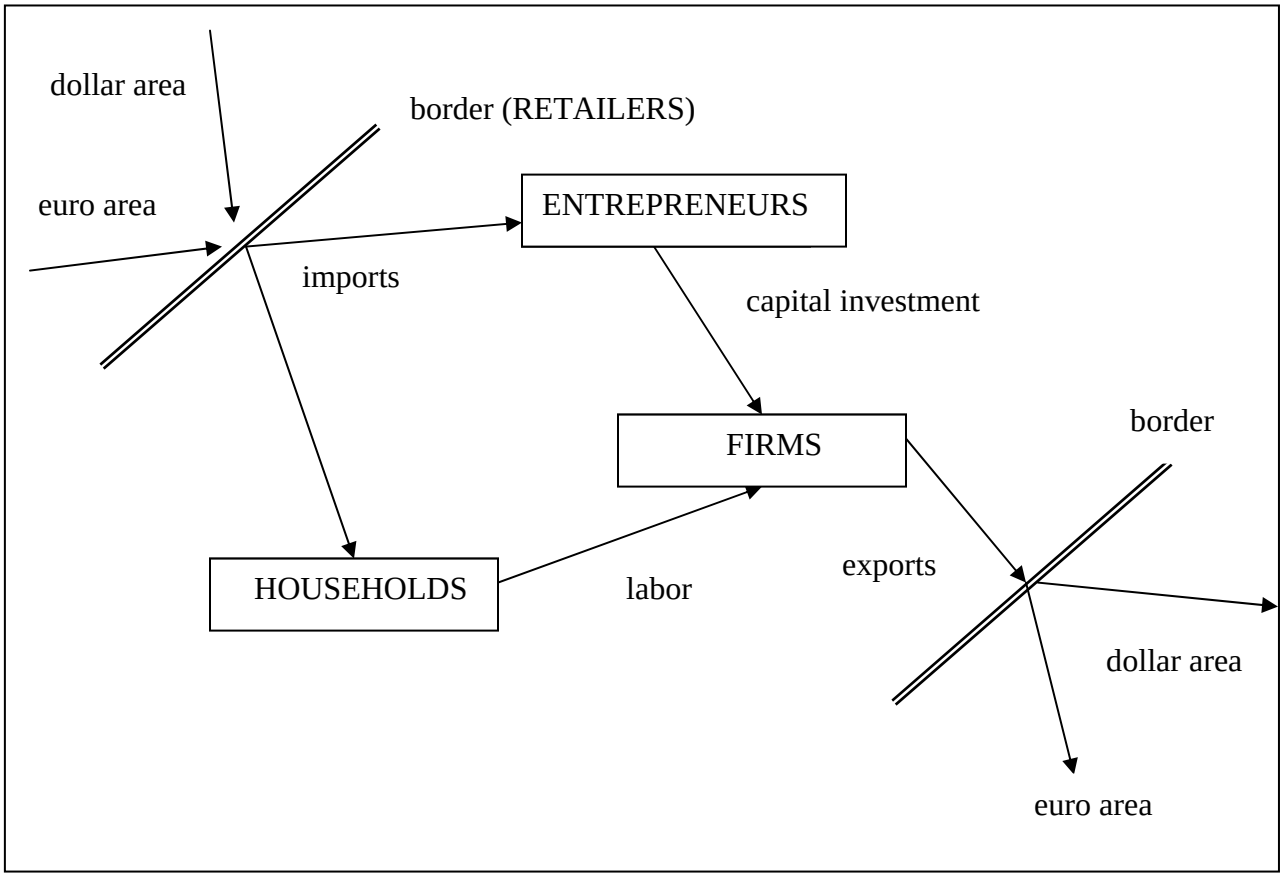
Source: McKinnon and Schnabl (2003)
Note: "East Asia" is defined as the following 8 countries: Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand.

Figure 3: Japanese FDI into East Asia and the yen-dollar exchange rate, 1980-2001 (yearly data)

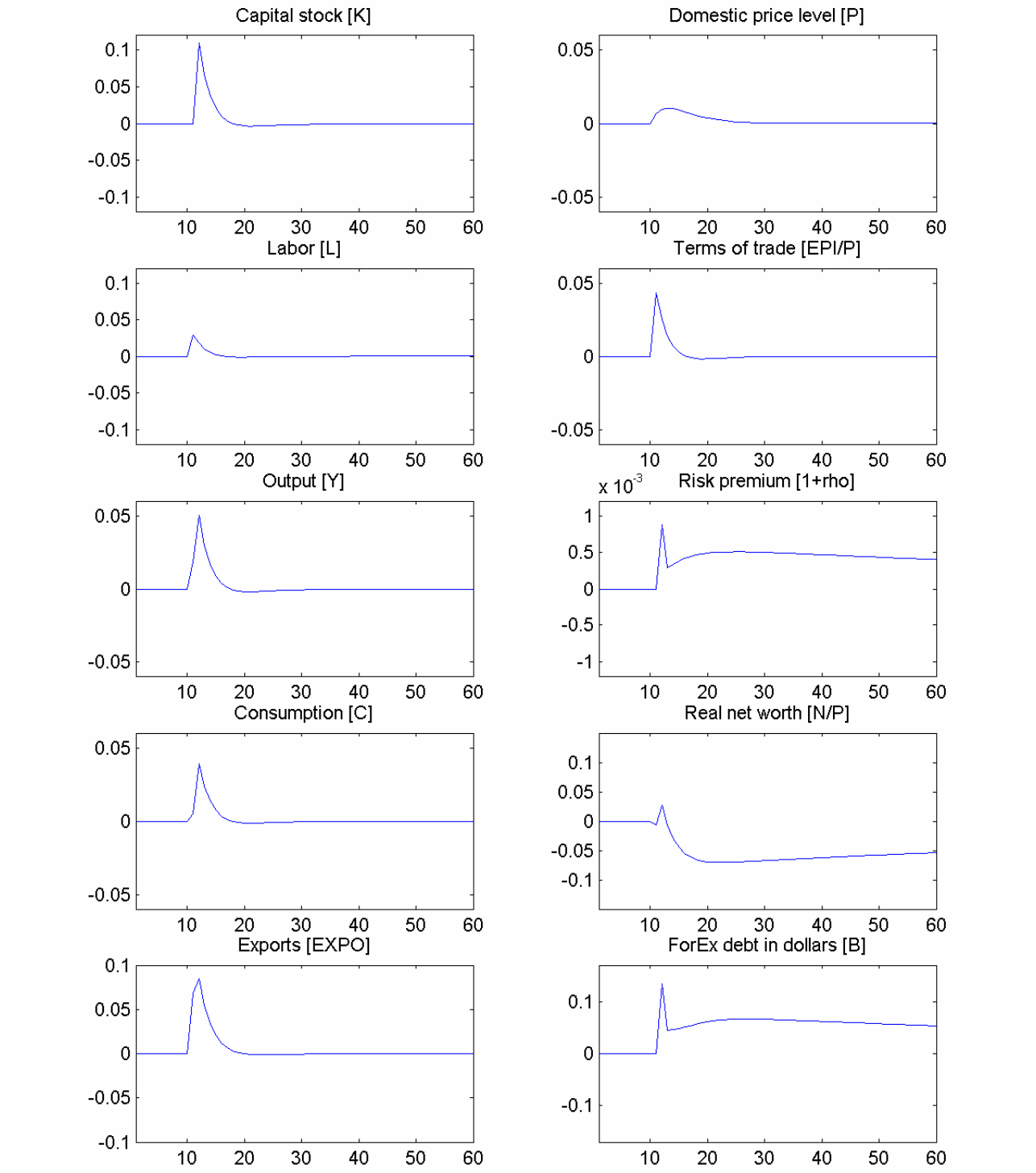


Source: McKinnon and Schnabl (2003)
Note: "East Asia" is defined as in Figure 2.

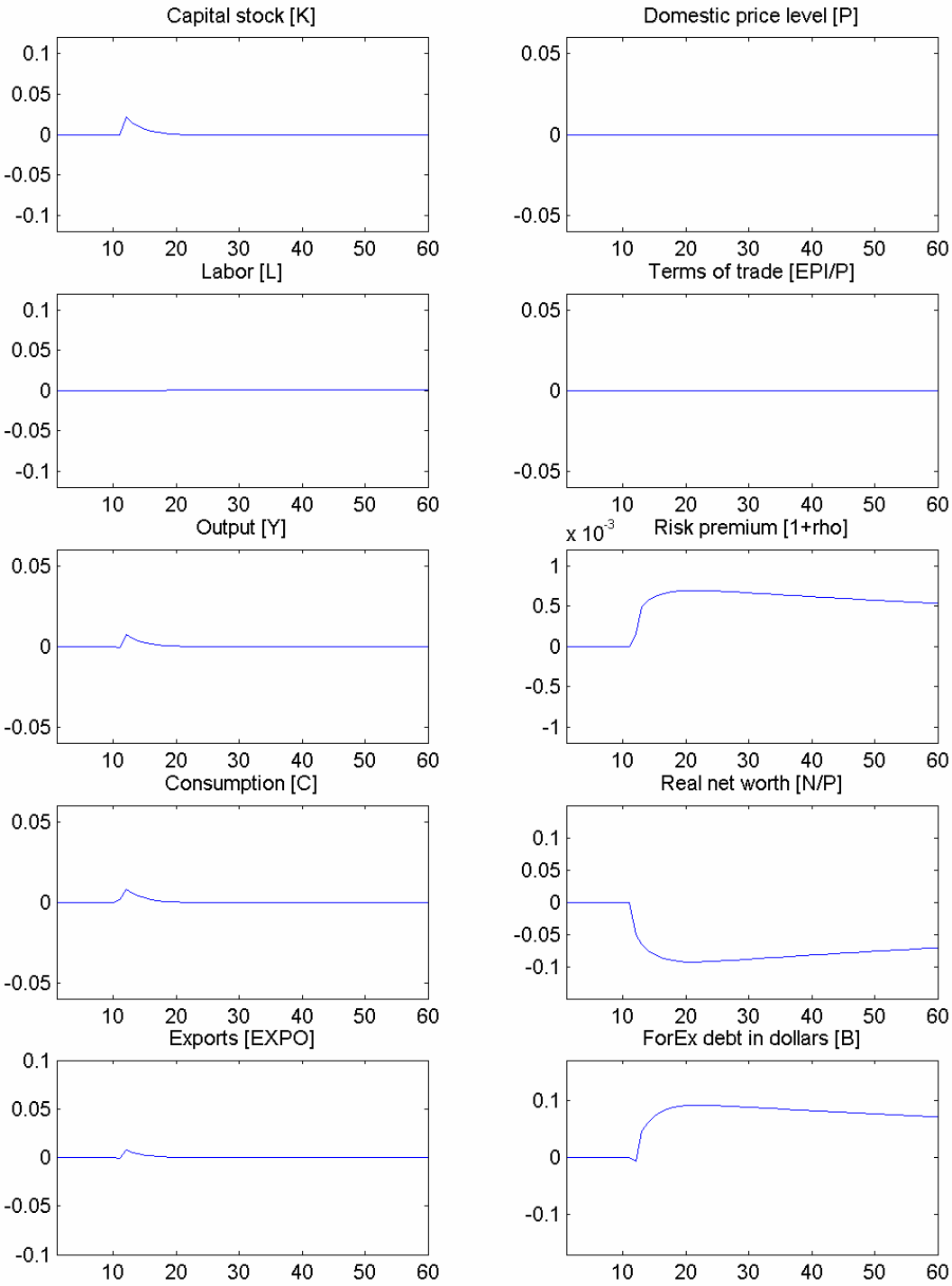
Figure 4: Flow of goods in the small open economy



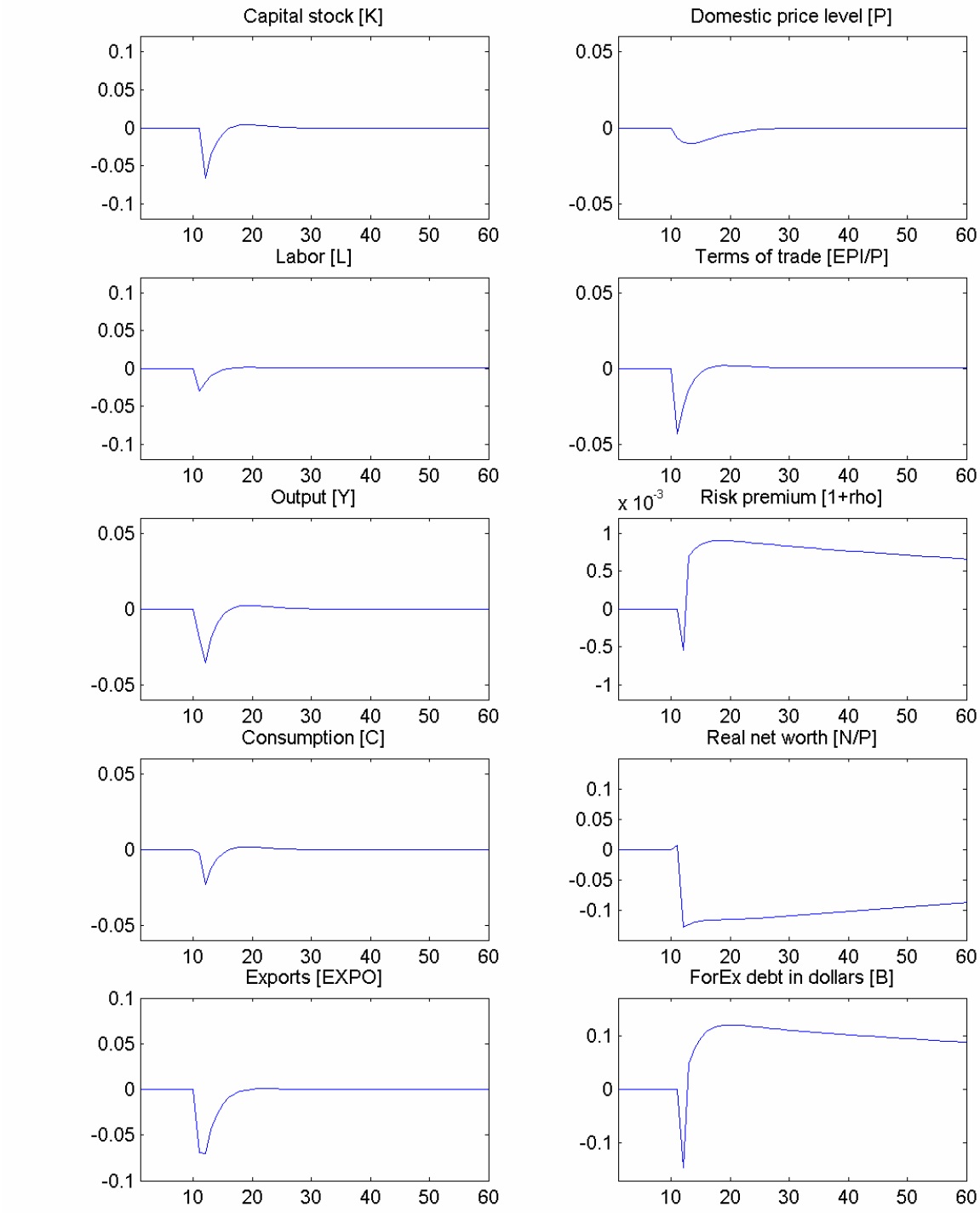
<u>Figure 5</u>: Impact of a 10% depreciation of the euro against the dollar under a euro peg



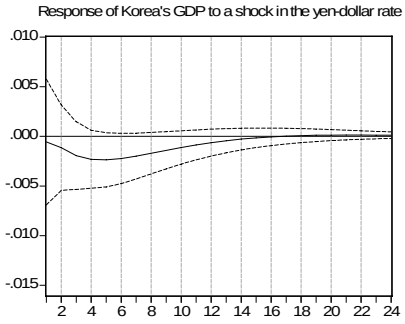
<u>Figure 6</u>: Impact of a 10% depreciation of the euro against the dollar under a trade-weighted basket peg



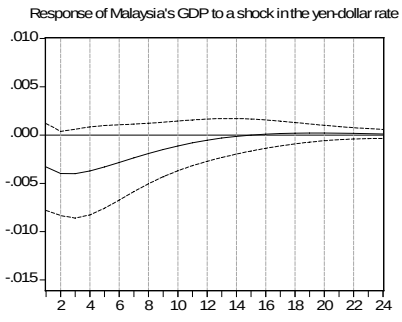
<u>Figure 7</u>: Impact of a 10% depreciation of the euro against the dollar under a dollar peg



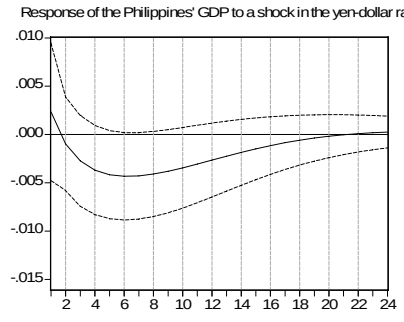
<u>Figure 8</u>: Impulse response functions for the output of East Asian countries (in response to a one-standard-deviation, one-period exchange rate shock)



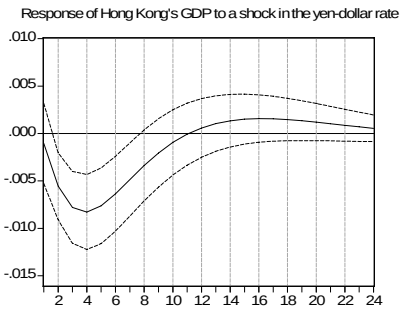
Q2:1980 – Q2:1997 (69 obs.)



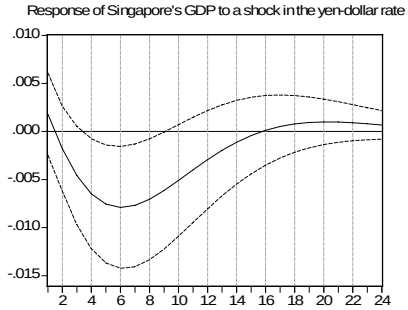
Q2:1988 – Q2:2005 (69 obs.)



Q2:1985 – Q2:1997 (49 obs.)

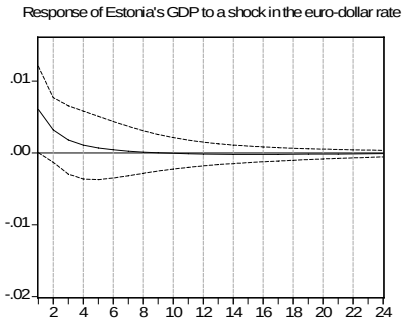


Q1:1984 – Q1:2006 (89 obs.)

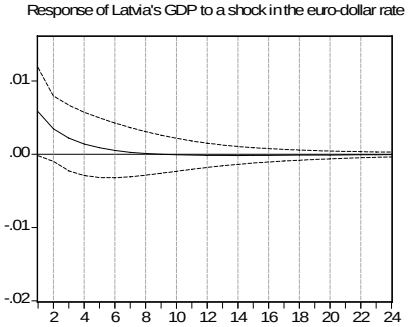


Q4:1984 – Q4:2005 (48 obs.)

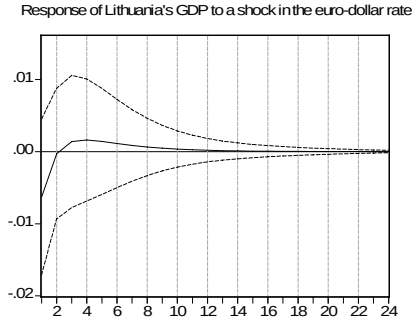
<u>Figure 9</u>: Impulse response functions for the output of Baltic countries (in response to a one-standard-deviation, one-period exchange rate shock)



Q2:1993 – Q4:2005 (51 obs.)



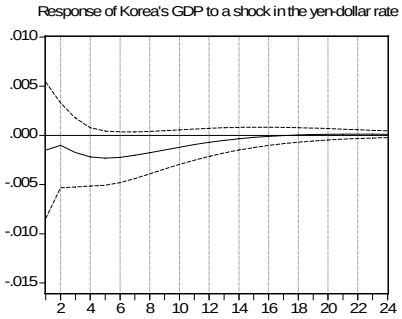
Q2:1994 – Q4:2004 (43 obs.)



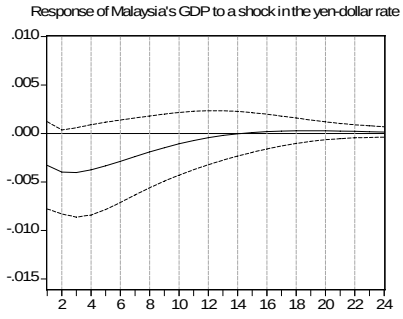
Q2:1994 – Q4:2001 (31 obs.)

APPENDIX

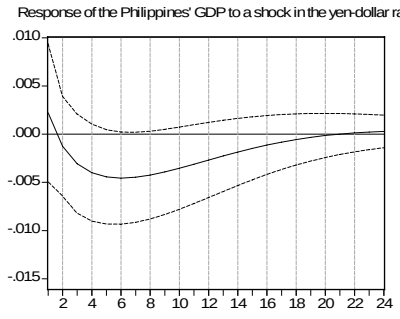
<u>Figure A10</u>: Generalized impulse response functions for the output of East Asian countries (in response to a generalized one-standard-deviation, one-period exchange rate shock)



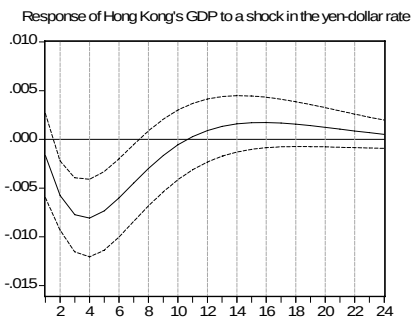
Q2:1980 – Q2:1997 (69 obs.)



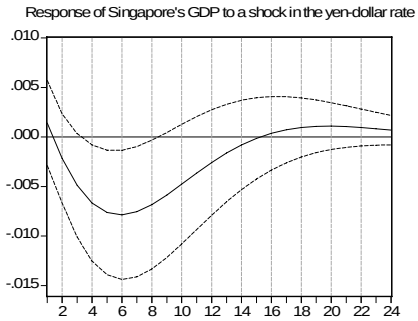
Q2:1988 – Q2:2005 (69 obs.)



Q2:1985 – Q2:1997 (49 obs.)

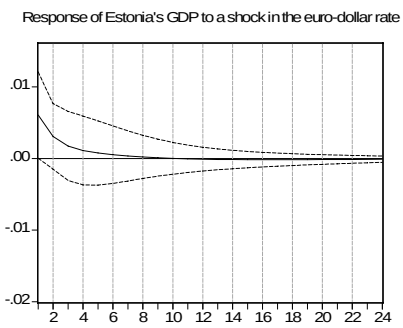


Q1:1984 – Q1:2006 (89 obs.)

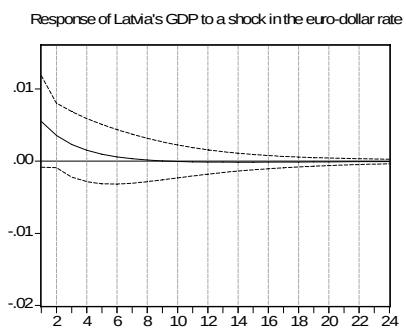


Q4:1984 – Q4:2005 (48 obs.)

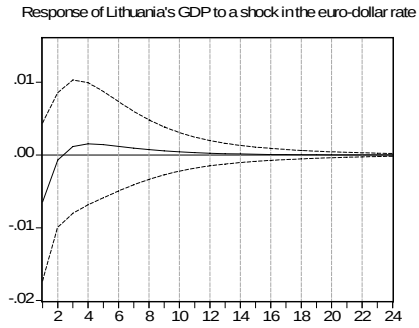
<u>Figure A11</u>: Generalized impulse response functions for the output of Baltic countries (in response to a generalized one-standard-deviation, one-period exchange rate shock)



Q2:1993 – Q4:2005 (51 obs.)



Q2:1994 – Q4:2004 (43 obs.)



Q2:1994 – Q4:2001 (31 obs.)