

A New Look at Pass-through

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Abstract: This paper examines the relationship between exchange rates and prices. Rather than assume exchange rate changes are exogenous shocks that affect prices, I use a long-run restrictions VAR to identify shocks and explore the way domestic prices, import prices and exchange rates react to a variety of shocks. Consumer price pass-through is nearly complete in response to some shocks, but low in response to others. Alternatively, import prices and exchange rates typically respond in the same direction, and pass-through seems quick. This supports the idea that import prices are set in the producer's currency and that lower CPI pass-through is a result of changes in quantities or margins further down the supply chain.

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SECTION I: Introduction

The way the exchange rate interacts with the real economy depends critically on exchange rate pass-through, the degree to which exchange rate changes are passed through to price level changes. Our typical view of pass-through (notional pass-through) is one where the exchange rate changes for an exogenous reason and we see how prices change over time. Given this view, pass-through plays a major role in determining the extent of exchange rate volatility, the response of the terms of trade and trade balance to exchange rate changes, and the optimal monetary policy and exchange rate regime.

When measured, though, pass-through seems to vary both across countries and time, and understanding the reasons for the different reactions of prices to exchange rate changes requires an examination of the root causes of exchange rate and price changes. The wide variation in previously found pass-through coefficients may in fact be nothing more than measuring the fact that different shocks were hitting the exchange rate at different times. I seek to remedy some of the problems of interpreting pass-through as measured by asserting that macro-level pass-through as typically measured (measured pass-through) can be misleading because it assumes that the change in the exchange rate is the shock itself. In this paper, rather than focus on the correlation of exchange rates and prices, I will identify fundamental shocks to the economy and test their effects on exchange rates, consumer prices, and import prices. Depending on the way in which exporters and others in the supply chain set their prices, we could expect the change in the exchange rate to be fully reflected in domestic import prices (full pass-through) or could expect foreign exporters to compress their profit margin to avoid drastic changes in the prices their customers face. The pass-through to the overall price level will depend on the way in which domestic and import prices interact and the reaction of the overall economy to the increase in import prices.

It is likely that the way price setters react will depend on why the exchange rate is changing. For example, during a hyperinflation, money grows, prices rise, and the exchange rate depreciates, generating a picture of full pass-through. At the same time, changes in foreign money supply levels may change the exchange rate and foreign price levels at the same time generating little or no change in import or domestic prices. In neither case is the law of one price nor purchasing power parity violated, yet these examples give very different pass-through coefficients when pass-through is simply measured as the change in domestic prices with respect to changes in the exchange rate. Alternatively, one might see changes in the exchange rate generated by real factors: changes in the world economy that require a change in the home currency to maintain internal and external balance. This may lead to exchange rate changes without any changes in domestic prices, while import prices may change. In this case, it seems that pass-through into the overall price level truly was incomplete.

Previous macro-level studies have measured the effects of changes in the exchange rate on domestic prices. Many, though, failed to adjust for the fact that foreign costs and the exchange rate may be changing at the same time. To combat these issues, various researchers have tried to control for changes in costs as well as

other pressures on domestic prices. Micro-level studies of a particular product or industry have had more success in creating sufficient controls, but then limit the ability for international comparisons due to lack of data availability. Even when econometrically valid pass-through coefficients are found, studies of different countries over different time periods often generate widely varying pass-through coefficients leaving us with no clear picture of the importance of exchange rate changes for domestic economic conditions.¹

The difficult methodological question is the appropriate way to identify the shocks an economy faces. While many of the examples above were monetary changes, we cannot simply control for changes to the money supply because money and monetary policy respond endogenously to many other variables. A large body of literature has developed surrounding the issue of the effects of monetary shocks or monetary policy shocks (Christiano, Eichenbaum and Evans (1999)). Unfortunately, as the literature shows, the assumptions regarding the short run behavior of money, prices, and other variables, which are needed to statistically identify monetary shocks, have a substantial impact on the results. Faust and Rogers (2003) provide a strong rejection of recursive ordering procedures that assume some variables can or cannot respond to other variables in the first period of a shock. They show that if one tests a wide variety of reasonable restrictions on the relationships between the variables, the responses to shocks can vary a great deal. The standard recursive identifying assumptions may be over-identifying restrictions that have been developed over time in a data-mining like manner as researchers looked for restrictions that provided sensible impulse responses (see Rudebusch 1998).

Instead of following the monetary policy structural VAR literature, the identification strategy pursued in this paper will be to rely on generally accepted theoretical predictions about long-run behavior of the variables to identify the shocks. This follows the work of Blanchard and Quah (1989) and Clarida and Gali (1994) among others. Using a simple open-economy model, I generate restrictions on long-run behavior of the variables. These assumptions are sufficient to identify the different shocks which can then be used to test variance decompositions of the variables and their impulse responses to the shocks. This allows us to examine both the responses of exchange rates and prices to various shocks and to examine the importance of different shocks to changes in these variables.

The model and methodology appear to generate sensible results. For example, supply shocks lower prices and appreciate exchange rates. Nominal shocks temporarily increase output and increase all nominal variables. The results and variance decompositions are consistent with most macro models as well as many previous studies using this methodology, and the results appear to be robust to various changes to the model. The pass-through related results provide answers to a number of questions. Our new measure of the pass-through ratio (the change in prices divided by the change in exchange rates) varies by shock. While this is sensible, it helps answer why measured pass-through can vary across country and time. It helps explain why previous pass-through history may not be a good indicator of prices response to changes in the exchange rate,

¹ For literature reviews, see Menon (1995) and Goldberg and Knetter (1997) in addition to section 3 of this article.

and suggests that rule of thumb policy making behavior, e.g. a 10% devaluation will lead to a 1% increase in inflation, are poor rules to live by. The fact that pass-through is different with respect to a demand shock and a nominal shock is supportive of Taylor's (2000) suggestion that pass-through will be lower in low inflation environments.

At the same time, the measure of the import price pass-through ratio does not vary substantially across shocks. Supply, demand, and nominal shocks all change import prices and exchange rates in the same direction with pass-through ratios of roughly one. This is evidence that local currency pricing at the wholesale stage is not a widely pursued strategy and that the reason consumer price pass-through is low must be found somewhere else in the supply chain. The results also provide something of a bridge between the results of Campa and Goldberg (2002) and many micro studies, which assert import price pass-through differences across countries can be explained by micro factors such as industrial organization, and Taylor's hypothesis, which suggests the inflationary environment should be important to pass-through. These results also match some new developments in new open economy models which incorporate producer currency pricing into intermediate import goods but local currency pricing for consumer goods at the retail level.²

Finally, there are significant differences across countries, but it does not appear pass-through is uniquely different in developing countries as much as the fact that some developing countries have had high inflation and high inflation does seem to generate higher pass-through even in response to demand shocks.

The next section briefly reviews the problem of pass-through studies. Section 3 discusses previous empirical pass-through studies as well as previous models with long-run identifying restrictions. Section 4 explains the long run restrictions and the empirical technique. The fifth section discusses data and results, and section 6 considers alternative specifications of the model. Section 7 discusses the implications of the results and concludes.

2. A simple exposition of the problem

Because both exchange rates and prices may respond to the same shock, a simple econometric specification may generate different measures of pass-through depending on what caused the exchange rate to change. Some studies have used essentially the econometric formulation:

$$\Delta p = a + b\Delta s \quad (1)$$

where p represents the log of prices, and s equals the log of the nominal exchange rate (home in terms of foreign). To illustrate the drawback with such a specification, I consider a simple model of exchange rates, money, and prices and demonstrate the problems some analyses of pass-through may encounter.

We can examine a basic model motivated by purchasing power parity (PPP) and the quantity equation with constant velocity and number of transactions. Let m equal the log of money, and * denote foreign variables.

² See for example Obstfeld (2001), Engel (2002) and Bacchetta and van Wincoop (2002).

$$s = p - p^* \quad (2)$$

$$m = p \quad (3)$$

$$m^* = p^* \quad (4)$$

$$s = m - m^* \quad (5)$$

This model could be derived from a monetary model of the exchange rate or from a more fully-specified model (Bachetta and Wincoop (1999) and Bergin and Feenstra (2001) arrive at $s = m - m^*$ in their models). Obviously, more developed dynamics would add realism, but this basic idea is enough to show the problem with many macro studies of pass-through. For simplicity, the only shocks to the system are random policy shocks to m and m^* .

A change to m will generate changes in both s and p , and if the equation 1) were tested, the coefficient b would be 1. Measured pass-through will appear full and complete, and because it is assumed to do so in the model, PPP will hold. Alternatively, if m^* changes, p^* moves by the same amount in the same direction, but s moves in the opposite direction (i.e. $\Delta m^* = -\Delta s$). In this case there is no change in the domestic prices of foreign goods as foreign costs and the change in exchange rates perfectly cancel out one another, and the estimate for b will be zero. Thus, without violating PPP or having any pricing dynamics such as pricing to market (PTM), we find that simple regressions may generate very different results based on the shock.

One could try to avoid the endogeneity problem by using lagged exchange rate changes, but the problem could still exist. If prices respond to money with a lag, and yet exchange rates change immediately, then the same scenario applies. That is, if $\Delta p(t)$ equals $\Delta m(t-1)$ and $\Delta s(t)$ equals $\Delta m(t)$, then running the regression $\Delta p(t) = a + b\Delta s(t-1)$ will still generate coefficients of 1 when there are shocks to domestic money and zero when there are shocks to foreign money.³

There are two problems going on. First, even when PPP holds, we can still generate measured pass-through coefficients of zero. This creates the appearance that pass-through is incomplete when, in fact, foreign prices and the exchange rate are moving in opposite directions generating no change in the import or domestic prices. Second, we have the problem that if shocks affect s and p together, it may appear the shocks to s are causing changes in p . Here, measured pass-through is estimated correctly, but it is not the exchange rate generating the changes in prices, they are both simply reacting to the same shock. That is, measured pass-through does not connect to our notional view of pass-through. One problem with many cross-country studies is that if some countries face large anticipated shocks to m (such as Latin America in the 1970's and 80's) then we will see very high measured pass-through coefficients, but there may be nothing different about the way exchange rate changes affect prices in these countries, we are simply observing large monetary shocks.

³ Engel and Morley (2001) suggest the opposite problem, that exchange rates move back towards PPP more slowly than prices. In either case, differential speeds of adjustment will cause estimation problems.

One could attack half the problem by recognizing that foreign prices or costs may be changing as well. This would call for estimating $\Delta p = a + b_1 \Delta s + b_2 \Delta p^*$. Under this model, the problem of a zero coefficient on b is removed, but when prices respond more slowly than exchange rates, the problem persists since s and p^* will change in different periods and p will not change at all. In addition, other shocks can affect s and p together such as relative demand.

Thus, the overall problem is the endogeneity of the exchange rate and prices. To understand the interaction of exchange rates and prices, we need to examine those factors that are driving exchange rates and prices simultaneously.

3. Previous literature

3.1 Pass-through studies

A wave of interest in pass-through followed papers by Dornbusch (1987) and Krugman (1987) which considered the phenomenon of pricing to market as a possible reason the US trade balance was not reacting to changes in the exchange rate. More recently, interest has been rekindled by the recognition that the currency in which imports are priced has important effects on optimal monetary policy in some models. A great deal of empirical work has been done, and while the methodologies have differed, all of these studies consider the exchange rate change the shock itself. They are partial equilibrium models which do not investigate the causes of the change in the exchange rate and how that determines its impact on prices. Comprehensive surveys of previous micro level work include Goldberg and Knetter (1997) and Mennon (1995).⁴

More relevant to this project are the studies that have focused on macro level indices. Early work includes Dornbusch and Krugman (1976) and Sachs (1985). In both cases, the papers do not address the problem that exchange rates and prices are driven by common shocks, nor do they control for foreign price changes in any way.⁵ Woo (1984) discusses some of the issues raised in this paper regarding the fact that both exchange rates and prices are endogenous variables and that simple reduced form models are mis-specified. While he controls for more variables and uses instrumental variables to control for omitted variables and generate more robust results, we are still left unsure about the way in which different shocks that cause changes in the exchange rate may generate different results.

Other more recent papers have not all heeded the warnings in Woo or the comments on the earlier papers. Calvo and Reinhart (2000) run a simple VAR in exchange rates and prices to test the effect of changes in exchange rates on prices. Goldfajn and Werlang (2000) seek to explain the rate of inflation based on

⁴ Estimates over 50% but well under 100% pass-through are common. As Mennon shows, though, the range of the results is wide both across industries, time, and country, and even within the same country and industry.

⁵ In discussion following the Dornbusch and Krugman paper, Poole commented that it was problematic to refer to the change in the exchange rate as exogenous without explaining the shock that caused the change. Sachs comments that he is assuming output and foreign prices are the same for different paths of the exchange rate. This, however, seems quite unlikely if the exchange rate is responding to fundamental shocks that strike the economy. In a comment on the paper, Obstfeld (1985b) is skeptical that there could be an exogenous shock to the exchange rate that leaves all other variables unchanged.

exchange rate changes, the output gap, initial inflation, real exchange rate overvaluation, and openness. While trying to control for other shocks to prices is helpful in their results, they still do not try to control for different shocks to the exchange rate. McCarthy (2000) tries to separate the shocks driving prices at different stages of the distribution chain using a short run restrictions VAR. This, however, necessitates deciding on short run relationships to identify the model.⁶

Other studies (beginning with Kreinin (1977)) have pursued more of an event study methodology. These studies attempt to find exogenous shocks to the exchange rate by the focusing on large discrete changes, but in many cases, the devaluations were necessitated by underlying fundamentals of the economy making the exchange rate change dependent on the underlying shocks.⁷ Burnstein *et al* (2002) study nine recent devaluations and again find that consumer prices do not respond dramatically to exchange rate changes, but import prices do move more substantially. They posit a model where distribution costs and substitution from imports towards lower quality domestic goods explain the lack of CPI response.

Studies try to explain the differences in pass-through with a variety of reasons including currency contracts, industry concentration, import competition, and oligopolistic pricing dynamics. Only Klein (1990) discusses how different causes of shocks to the exchange rate should generate different reactions in the economy, but there has been no empirical work on the subject, nor has it been followed up in the literature.

Taylor (2000) has recently used a simple staggering model to show how the persistence of the shock (in this case the exchange rate) as well as the percentage of firms hit by the shock will determine how firms respond. From this model, he generates a hypothesis that the pass-through will be endogenous to a country's inflation environment. Gagnon and Ihrig (2002) find support for this hypothesis when they look at pass-through into consumer prices. On the other hand, Campa and Goldberg (2002) find that in general, pass-through into import prices can be explained primarily by microeconomic factors such as industry competition or the import bundle of the country. By examining both consumer and import prices and a variety of shocks, this paper can help inform this debate.

Pass-through has also become an important part of the debate in new-open economy modeling. Betts and Devereux (2000) and Devereux and Engel (2003) note that the optimal monetary policy and exchange rate regime in Obstfeld and Rogoff new open economy models is different if import prices are sticky in the price of the consumer not the producer. Obstfeld and Rogoff (2000) counter that terms of trade indices tend to move with exchange rates, implying import prices are set in producers' currencies. Obstfeld (2001) shows that even if one holds consumer prices fixed in local currency, pass-through into import prices of intermediate goods

⁶ In addition, McCarthy uses local price of oil to identify supply shocks, but this will include the exchange rate effect. Thus, much of the exchange rate effect may be mixed into the supply shock.

⁷ Amitrano *et al* (1997) and Gordon (1999) note that inflation was not rampant following the 1992 EMS devaluations and that a conventional wisdom has grown that some countries that devalued received a macroeconomic free lunch, faster growth without any inflation. Both studies conclude that there was in fact no free lunch and focus on the fact that other factors, notably the policies of the countries which devalued, had a significant impact on the subsequent level of inflation. By examining other factors that could be generating price changes, these studies recognize that prices are responding to multiple shocks. They do not, though, focus on how these shocks may also be generating the exchange rate changes.

will lead to expenditure switching by firms and still generate conclusions in line with earlier Obstfeld Rogoff models such as Obstfeld and Rogoff (1995 or 2000).⁸

3.2 Open Economy Long Run Restrictions Models

While previous pass-through studies have not focused on underlying shocks, there are a number of open-economy studies that have followed the Blanchard-Quah long run restriction methodology. Previous Blanchard-Quah style open-economy studies, though, have not aimed at uncovering insights into pass-through.⁹ In addition, the earlier Blanchard-Quah style studies have focused primarily on G-3 or G-5 countries and usually have used bilateral relationships with the US. Since so much trade is invoiced in dollars, focusing on the US may cause incorrect generalizations about pass-through. These studies include Lee and Chinn (1998), Eichengreen and Bayumi (1993), Lastrapes (1992), and Canzoneri *et al* (1996).

Methodologically, the previous works closest to this study are Clarida and Gali (1994), Weber (1997), and Rogers (1999). These studies, though, mix domestic and foreign price shocks in the price shock. I choose instead to keep the foreign price shock separate in order to be able to examine the nominal exchange rate as well as the real exchange rate. Because these studies do not include the nominal exchange rate, they cannot test how important nominal shocks are to the nominal exchange rate or how prices and exchange rates interact. Also, they examine bilateral relationships with all variables defined as $x-x^*$, so they do not examine import prices or pass-through (bilateral import prices are rarely available). In addition, by isolating the domestic nominal shocks we may find whether countries with traditionally high measures of pass-through have that result due to historically large nominal shocks. If so, that is a variable that can in fact be controlled by better domestic monetary policy institutions.

4. Empirical methods

The general goal of the paper is to discover fundamental shocks to the economy and test the reactions of exchange rates and prices. One could try to uncover these shocks using standard recursive identifying restrictions, but the ordering often has a strong impact on the results. Alternatively, one could simply specify first period reactions to identify the model. In this case, though, the immediate reaction of prices and exchange rates is of central interest, and thus it seems a different methodology is needed. The Blanchard-Quah methodology flows from the restriction that certain shocks cannot affect the level of certain variables in

⁸ Obstfeld (2002) further defends the expenditure switching channel with more evidence of substantial pass-through into import prices and discussion of firm level responses to exchange rate changes. Bacchetta and van Wincoop (2002) begin from the observation that pass-through is lower into CPI than import prices and show that pricing decisions by firms can generate such dynamics if there is sufficient locally produced competition at the retail level. Engel (2002) provides a discussion of the various pricing alternatives and their impact on optimal policy. Choudhri *et al* (2002) examine pass-through with a short run restrictions VAR and compare the results to a variety of new open economy models. See also, Engel (2000), and Engel (2001). A related literature examines how the degree of pass-through may influence exchange rate volatility. See Devereux and Engel (2002) and Devereux, Engel, and Storgaard (2003).

⁹ Many studies have focused on the real exchange rate. Clearly, the extent to which prices and exchange rates move together is studied when one examines the real exchange rate, but there is no focus on import prices or the different individual reactions of exchange rates and prices.

the long run. This allows us to leave the short-run reactions free and enforce the long-run assumptions from the above model to identify the shocks.

A simple model based on an ISLM framework and similar to Clarida and Gali (1994) based on Obstfeld (1985a) can be used to generate a number of long run restrictions on the data. Appendix I. walks through the derivation; the intuition, though is quite simple. The restrictions that result are compatible with most open economy models. The intent of the model in the appendix is not to provide a specific model to be tested as much as to show that these sensible long run restrictions can be generated by a reasonable model. The restrictions are that only supply shocks can affect industrial production (y) in the long run; only supply and relative demand shocks can have a long run impact on the real exchange rate (q); both these shocks and nominal shocks can affect long run prices (p); all these shocks and foreign price shocks can influence nominal exchange rates (s); finally, all shocks can change import prices (p_m) in the long run, but import price shocks cannot have long run impacts on other variables.

It should be noted that the first restriction implies there is no long run impact on the industrial production from a shock to relative demand. Thus, terms of trade shocks do not have long run impacts on industrial production. While one may generally believe demand or terms of trade affect output. The logic is that in the long run, the industrial production of a society is determined by the supply side productive capacity of an economy, and that prices will adjust so that all quantities are sold.

It is also important to clarify the relative demand, nominal, and foreign shocks. A shock to relative demand will be found by any long run change in q which is not caused by changes to industrial production. A nominal shock would thus be the changes in prices not caused by changes in supply or changes in the real exchange rate, that is, those changes to prices that are offset by foreign prices or exchange rates (thus not changing q). The definition of the relative demand shock has two important implications. First, pass-through into consumer prices cannot be complete. That is, s and p cannot change by the same amount in the long run, or there would not have been a change in the real exchange rate. This issue is revisited when we examine the results. Second, the fact that relative demand is found through long run changes in the real exchange rate by definition implies a failure of Purchasing Power Parity (PPP) in the long run as an implication of PPP is that real exchange rates are constant over time. PPP may fail for a variety of reasons, but persistent long run failures generally require long run changes to the economy. In his well know survey of PPP, Rogoff (1996) notes some of the leading explanations for long run failures of PPP such as the Balassa Samuelson effect and associated predictions that countries with positive productivity supply shocks in the tradables sector will see real appreciations. Changes in government share in the economy, relative wealth, or tastes may all generate changes in relative demand the require changes in relative prices of goods across countries, or long run real exchange rate changes. The fact that the model only allows the real exchange rate to change with respect to changes in relative demand or supply shocks is consistent with these ideas. Real shocks can cause long run

failures of PPP and hence long run changes in the real exchange rate, but nominal shocks (whether home, foreign, or import price) cannot.

Shocks to the nominal exchange rate are changes in foreign prices. It may seem odd that shocks identified through permanent moves in the nominal exchange rate are called foreign price shocks. The reason for this is that if the nominal exchange rate changes permanently without altering the real exchange rate or domestic prices, the change must have taken place in foreign prices and the nominal exchange rate simultaneously. That is, since $q = s + p^* - p$, (all variables in logs) if Δq and Δp both equal zero, this implies $\Delta s = -\Delta p^*$. In fact, Campa and Goldberg (2002) use this result to generate their foreign price series from information on domestic prices, real exchange rates, and nominal exchange rates. I include the nominal exchange rate instead of p^* directly in the regressions because we are interested in the response of s to various shocks more than we are the response of p^* .¹⁰ While typical shocks are measured as movements up in the variables, because $\Delta p^* = -\Delta s$, the model will identify shocks from movements up in s , meaning a foreign price shock will actually be a fall in foreign prices.

The other necessary clarification is the relationship between import prices and domestic prices. As noted above, a shock to import prices alone (say to the markup) will not change domestic prices in the long run. Domestic prices are anchored by the money demand equation. Only changes to the money supply or the production of the economy can change the prices. If import prices change, for reasons other than those, we assume that in the long run, the economy adjusts in a way that prevents the overall price level from becoming incompatible with money demand. That is, given a change in import prices, the import quantities and perhaps domestic prices will change so that the overall price level is consistent with the money demand equation. This is consistent with the ideas expressed in Burstein, Eichenbaum and Rebelo (2002) and the structure of the model in Obstfeld (2001) and Bacchetta and van Wincoop (2002).

While the model specifies the long run reactions, it does not provide any restrictions at all in the short run. The model also shows that if output is demand determined in the short run (this can be due to sticky prices or due to monopoly power of producers etc.) then we will see more complex interactions of the variables, and as a result, all shocks will affect all variables in the short run. The sticky prices allow many variables to influence current output and since output affects all other variables, all variables can influence one another.

The Blanchard Quah methodology is described in appendix II. It uses the long run restrictions (which are lower triangular) to recover the short run reactions (which are unrestricted) and then uses that matrix to identify shocks, generate impulse response functions, and calculate variance decompositions. Since the variables of interest, y , q , p , s , and pm all tend to exhibit non-stationarity, open-economy Blanchard Quah

¹⁰ I rerun the results with p^* derived in this manner instead of s . Nothing in the results change except the behavior of p^* in response to other shocks. That is, the response of other variables to shocks to p^* are identical (with opposite sign) to those to the nominal exchange rate variable.

studies typically use log first differences when running the vector autoregressions.¹¹ This means when we say a shock can have no long run effect on a variable, we are requiring that the sum of the effects on the change in that variable are zero. For example our restrictions are equivalent to forcing the sum of all effects on Δy from any shock other than a supply shock to be zero. Thus, in the long run, y will not have changed as a result of any shocks other than supply shocks.

The VAR is run with 2 lags. The lag length is chosen based on Akaike information criteria and Schwartz information criteria as well as by examining the adjusted R^2 of the equations. The statistics tend to prefer one or two lags.¹² More lags can improve the adjusted R^2 for some equations (most notably for industrial production). Additional lags, though, also use up a great deal of degrees of freedom considering there are 5 variables in the system. Additional lags did not appear to dramatically alter the results based on cursory analysis of alternate specifications.¹³ To test the level of significance of the results, confidence intervals for the impulse response functions have been generated using bootstrap procedures with 500 replications.¹⁴

The procedure is performed both on the pooled data set comprising of 1499 observations and on each individual country as well as various country groupings. The pooled results obviously impose some unrealistic assumptions, namely that the relationships are identical across all countries. Heteroskedasticity would obviously be a problem with any conventional standard error procedure, but the bootstrapping process should yield consistent estimates.

5. Data and Results

5.1 Data

The data are taken from the IFS CD-Rom and countries are chosen based on data availability. Industrial production is used in place of real GDP in the interest of data availability.¹⁵ The real exchange rate series is based on relative CPI.¹⁶ The exchange rate indices in general are multilateral, trade-weighted, indices.

¹¹ For all five variables, I was unable to reject unit roots for all countries. In addition, cointegration tests were performed on the levels. It did not appear that there were significant cointegrating relationships. These results match results reported in Canzoneri et al (1996), in Campa and Goldberg (2002), and many other studies.

¹² Quite often the different statistics suggest different lag lengths for the same country. I choose to simply use two lags as it seems to be a reasonable choice for all countries despite not being the preferred method for certain countries based on certain statistics. The choice is consistent with the literature. Lee and Chinn use two lags while using quarterly data based on AIC and SBIC, Weber uses four lags with monthly data, Canzoneri et al use four lags with quarterly data, and Eichengreen and Bayumi use two lags with annual data based on SBIC.

¹³ Even adding more lags to the industrial production equation does not appear to alter the regression significantly nor improve the prediction of industrial production based on non-industrial production variables substantially.

¹⁴ As is fairly standard in this literature, the VAR is run on the actual data to generate a set of residuals. These are drawn from randomly to create new data and rerun the VAR. The bootstrapping exercise is repeated 500 times to generate standard error bands for the point estimates.

¹⁵ In a few instances, manufacturing production was used instead of industrial production because industrial production was not available. In almost all cases, the industrial production series was seasonally adjusted. Thus, to make sure each country was treated in a similar fashion, I seasonally adjusted series that were reported in unadjusted form.

¹⁶ The exchange rate series are not directly from the IFS CD-Rom. For most countries, these series did not begin until 1979. In addition, for industrialized countries, the available nominal and real exchange rate series (neu and reu) is based on unit labor values not CPI and only includes trade with other industrialized countries. Thus, I create my own real

Both nominal and real exchange rates are set such that a rise in the index is a depreciation (as in standard international macro theory). The import prices are based on direct prices, not unit values. This choice is motivated by concerns in the literature regarding the usefulness of some of the unit value based data,¹⁷ as well as concerns from preliminary explorations of the data.¹⁸ This choice also, though, severely restricts the sample, limiting it to 16 countries.¹⁹ The time sample is 1973:1 to 1999:4 using quarterly data. For a few countries data is missing at the start or end of the sample. All data are quarterly and quarterly dummies are included to remove the effects of seasonal variation on the results.

5.2 Pooled Impulse Response Function Results

We begin with the pooled results. The model generates sensible patterns with regards to both variance decompositions and impulse response functions. Figures 1 and 2 show the impulse response of each variable to the five shocks with a confidence bound showing the 5th and 95th percentiles from the bootstrapping exercise.²⁰ The shocks are assumed to happen in period 1, so the response at time 1 is the contemporaneous response. The responses shown are of the log level of each variable (calculated by summing up the response of the log deviations). Thus, when something has changed by an amount of .01, that is a 1% change in the level of the variable in response to the shock.²¹ Looking first at the pooled data, we see that supply shocks (the first column of graphs) permanently lift the level of industrial production, have a questionable effect on real exchange rates, lower prices over time, appreciate nominal rates over time, and lower import prices over time. All these effects are consistent with most international macro theory.

[INSERT FIGURE 1 AND FIGURE 2 ABOUT HERE]

Demand shocks (a fall in relative demand generating a real exchange rate depreciation) have a small, statistically insignificant, positive impact on output in the short run, depreciate the real exchange rate permanently, raise domestic prices a small amount (though the impact loses statistical significance over time), depreciate the nominal exchange rate, and raise import prices permanently.

Nominal shocks have a positive impact on industrial production which lasts almost 4 years, fading slowly after an initial large reaction. There is no “hump-shape” as is often discussed in the literature, where the reaction grows in the first few periods before declining, though there is certainly room in the confidence

exchange rate and nominal exchange rate series using the same weights the IMF uses (kindly provided by the research department) in creating these series. Weights using all countries, not just industrialized, are available for all countries and match the import price indices better. Due to a lack of CPI data to use in the creation of the real exchange rate index, China and Hong Kong had to be excluded.

¹⁷ See Mennon (1995) for discussion and references to other researchers’ concerns over the use of unit values.

¹⁸ Countries with unit values instead of direct prices seemed to exhibit very different import price behavior.

¹⁹ The countries are: Australia, Austria, Chile, Colombia, Denmark, Finland, Germany, Greece, Hungary, Japan, Korea, Poland, Singapore, Switzerland, the UK, and the US.

²⁰ Due to non-normal distribution of the sample, the point estimate is not necessarily in the middle of the bands.

²¹ The size of the different shocks is determined by the data. Thus, the size of the response for any given country to a particular shock depends both on the responsiveness of the variable to the shock for that country and the size of the shock for that country. When, though, we compare the response of different variables (say s , p , pm) to a shock, that shock will be the same size for all variables, thus making comparisons fair. It is only cross-country comparisons where the size of the shocks can vary.

intervals for there to be one. In addition, 9 out of 16 individual countries do show such a shape with the hump coming between the second and fifth periods. Nominal shocks also temporarily appreciate the real exchange rate, though the effect is weak, and increase all the nominal variables by almost the exact same amount. The nominal exchange rate reaction is slightly smaller or slower than the consumer price index which is why there is a real exchange rate effect. In the end, the real exchange rate effect is zero and all nominal variables have moved up almost identically.²² This also implies that there is no evidence of over-shooting in the pooled results. This is not because prices move instantly to their long-run level, prices rise slowly over time as sticky price models expect; it is because the price level and nominal exchange rate both react at roughly the same rate after a nominal shock. They increase immediately and then continue to rise over time instead of exchange rates reacting immediately and prices catching up over time as in the overshooting model.

Foreign price shocks (seen as a depreciation in the home nominal exchange rate, which means the foreign prices have fallen) have effects that are not statistically different from zero for any variable except the nominal exchange rate. Since these shocks are changes in foreign prices that are balanced by the nominal exchange rate it is sensible that they should not substantially affect the domestic economy. There is a weak result that CPI and import prices rise, suggesting that the nominal exchange rate has gone up more than foreign prices temporarily. This generates a weak real depreciation. The lack of a long run real exchange rate response is in some sense an artifact of the methodology. Any shock that did generate a real exchange rate effect in the long run would be identified as a relative demand shock, not a foreign price shock. On the other hand, the methodology imposes no limits on the short run behavior, and other variables which cannot have long run responses do show significant short run responses (such as output's response to a nominal shock).

Finally, import price shocks appear to have small effects that fade quickly on a few variables (positive response of output, depreciation of real exchange rate, depreciation of nominal exchange rate, very small increase in domestic prices), but, in general, do not have significant impacts on any variables. With the exception of these import price shocks, most of the responses described above are significantly different from zero at the 95% confidence level (the ones that are not are the ones described as weak or questionable). Thus, not only does the model generate results that are sensible in direction, they are fairly statistically significant.

5.3 Pass-through Ratios

After making sure the model is generating sensible results, the primary interest is to see the relative behavior of s , p , and pm following the shocks. We can look at a pass-through ratio which measures the change in p divided by the change in s at the initial shock and four periods later as well as graphically examine the response to each of the five shocks. This does not correspond to our notion of pass-through where one looks at the change in prices in response to an exogenous change in exchange rates. Instead, I consider how much the exchange rate and price level change in response to a particular shock both immediately and four periods later.

²² The real exchange rate depreciates for many countries. It seems to be in high inflation countries that the price level moves more generating the real exchange rate appreciation. Since the result is stronger in these countries, it seems to dominate the pooled sample.

If the exchange rate does not respond much to the shock but prices do, the ratio may be in excess of 1 (more than 100%).²³ This maps more closely to the way macro pass-through is typically measured looking at the change in prices and change in exchange rates. The difference is that in this case, we are able to split out these reactions based on different shocks. This allows us to see how typically measured pass-through would look after different shocks to better understand the relationship. To examine notional pass-through more directly, that is the response of prices after an exogenous shock to the exchange rate, we can look at the responses of s and p and pm after a demand shock. Figure 3 panel 2 shows that prices move only 20% of the change in the exchange rate at first. In the long run, it is closer to 40-45%. The closing of the gap is not because the nominal exchange rate comes back towards PPP, though, it continues to move up, but because prices also move up closing the gap some. Given that the restrictions force the reaction to a demand shock to be incomplete, we will also want to examine the varying importance of these demand shocks across countries, not just the raw reaction (see sections 5.4 and 5.5).

[INSERT TABLE 1 ABOUT HERE]

Table 1 presents these statistics for the five shocks for the pooled sample and for different country groupings (see appendix table 1 for individual country statistics). One of the most notable things about the table is the response to nominal shocks. “Pass-through” into both CPI and import prices is immediate and complete. In fact, in the first period, prices have moved more than the exchange rate. After a year, the response is essentially unit pass-through and is measured fairly precisely. In other words, the response of all three nominal variables to a nominal shock is identical at the one-year horizon. While this result is not surprising in some sense, it does highlight the importance of which shock hits an economy. The examples above (e.g. a hyperinflation) anticipated this result, but it holds true even for smaller inflation rates. The fact that the contemporaneous response of CPI is more than one means that the real exchange rate appreciates briefly. Once again, this does not mean that nominal shocks have all their impact at period one; the nominal variables reactions grow over time, but they all react at roughly the same rate, making the ratio roughly equal to one.

It should be noted that for these responses, the long-run constraints are not enforcing the results. All three variables are allowed any response to nominal shocks in the long or short run. The only shocks that are constrained are the fact that CPI cannot have a long run response to foreign price shocks and neither CPI nor nominal exchange rates can respond to import prices in the long run. These constraints help lead to the odd behavior following import price shocks. Since the exchange rate cannot have a long run response, its reaction may be forced to zero. Since it is in the denominator, this means we are dividing by a number very close to,

²³ Interestingly enough, Gordon (1999) encounters pass-through well in excess of 100% in some cases. He does not include those results in his averages, considering them to be aberrant. The analysis here suggests that depending on the shock, we might not be surprised to see prices respond in excess of 100% of the exchange rate change, and thus, we should not be surprised to see measured pass-through in excess of 1.

and on either side of, zero. This contributes to the wild swing from 14 to -64 in the results and to the wide statistical confidence intervals. Responses to the first three shocks, though, are completely unconstrained.

For supply shocks, the immediate response is slightly stronger for CPI than import prices in the first period. Consumer prices respond most, then nominal exchange rates, then import prices. This leads to a ratio greater than one for CPI and less than one for import prices. Over time, though, the pass-through ratio is again close to one for both price indices and again is fairly precisely estimated.

On the other hand relative demand shocks have only a small effect on CPI. This makes sense, if a real depreciation comes as a necessary response to some external asymmetric shock between the domestic economy and the rest of the world, it is not surprising that the CPI does not respond.²⁴ Industrial countries and low inflation countries show an even smaller CPI response to a demand shock. The difference between the CPI responses of demand and nominal shocks are statistically significant as the confidence intervals for these shocks do not overlap. The import price level, though, does respond immediately and fully to these shocks. This represents our sense of notional import price pass-through. A change in s that is not coming through some sort of nominal shock. In this case, pass-through appears quite full. This implies that pricing to market is not entirely pervasive. Despite the lack of domestic price changes, the import prices are moving almost as much as the exchange rate.²⁵ This also bolsters the assumption of the model that even in the long run, the domestic price level does not have to respond to an import price shock.

Finally, we see that neither the CPI nor import prices responds strongly to foreign price shocks. While the CPI is constrained to have no effect in the long run, it actually has a stronger short run response than the import prices (though it is fading over time). In all cases, the confidence interval encompasses zero. The price series may not be responding because foreign prices are being offset by the exchange rate, thus necessitating no change in domestic prices or in import prices once translated into the home currency.

These results are confirmed by looking at the impulse response of all three variables to the shocks. Figure 3 shows the response of p , s , and pm to each of the five shocks. Once again, the most notable picture is the identical response of the three variables to nominal shocks. Supply shocks generate strong responses as well as ones that are quite closely correlated. The consumer price response to a demand shock is notably smaller than that of the nominal exchange rate and import price. Finally, one can clearly see the problem

²⁴ As noted, this result is forced by the restrictions as well. If both prices and exchange rates had changed, the shock would not have been a real exchange rate shock, as the real exchange rate would not have changed. Instead, it would have been a nominal shock. There could be a partial price response to shocks identified as demand shocks. The only way, though, we expect to see sustained price responses to a real exchange rate response is if the real exchange rate is changing because of price changes (that is a change in p with out a change in s). On the other hand, despite the long run restriction, there is no restriction on the short run relationship and other variables restricted in the long run do show short run responses.

²⁵ If pricing to market were pervasive, we would not think import prices would be changing without CPI changes. Compression of margins elsewhere in the supply chain or changes in what foreign goods are being purchased must be balancing out the import price increase.

having the s response in the denominator presents for the import price shocks as the s response hovers back and forth above and below zero generating wide swings in any measure dividing by the s response.

[INSERT FIGURE 3 ABOUT HERE]

While an exercise like this provides no single statistic to test in order to confirm or deny a theory, these impulse responses do present a clear message. The technique does seem to generate responses that match theory without having to constrain the short run reactions. More importantly for this study, we see that the pass-through coefficient one would measure by regressing a price index on the exchange rate and assuming the exchange rate was exogenous could vary dramatically depending on the shock a country experienced during the time of testing. A country with nominal shocks may appear to have unit pass-through while one with a number of real exchange rate or foreign price shocks will show very little pass-through. If the shocks are to foreign variables, it is possible for PPP to still hold and yet pass-through appears to be zero. Lastly, we see that the different response of import prices and CPI is not just one of degree, but may also be one of type in some cases. Whereas we might hypothesize that the pass-through to import prices is always uniformly higher as the more stages of marketing allow more margins to be compressed, this analysis shows that the shocks matter. Some shocks generate very large import price responses but no CPI response (demand), some shocks lead to a small response from both variables (foreign shocks), some shocks generate responses where CPI responds more than import prices (supply shocks in the first period) and finally, nominal shocks generate similar responses for the two.

5.4 Variance Decompositions

If exchange rates are driven solely by one type of shock, then we do not have to worry about the reactions to different shocks. If on the other hand, more than one shock affects the nominal exchange rate significantly or if different countries have different variance decompositions, then the results above that show different pass-through after different shocks may be important. Table 2 shows the variance decomposition (which shows how much each shock determines the changes in the variables) of the log difference of the variables at time intervals one through five and at time 20.

[INSERT TABLE 2 ABOUT HERE]

We see that the nominal exchange rate is driven by many different shocks. Supply (13%), demand (52%), nominal (27%) and foreign shocks (7%) can all have significant effects. Nominal shocks and real exchange rate (demand) shocks are the most significant shocks. In response to those two shocks, we saw a very different response of exchange rates, domestic CPI, and import prices, implying that which shock dominates which country at which time could be quite important.²⁶

²⁶ Industrial production is driven largely by nominal and supply shocks. Nominal shocks have a strong impact despite the fact that the identification strategy restricts nominal shocks to be those that do not have a long term impact on output. Thus, despite using the long run neutrality of money as a restriction this exercise shows a significant role of nominal shocks in the real economy. Real exchange rates move almost exclusively due to demand shocks in the pooled results. On a country by country basis, it is more common to find a role for nominal shocks. Home plus foreign nominal shocks

5.5 Country Variation

There is some variation across countries in impulse response functions and significant differences in variance decompositions. It has often been alleged that developing countries look different from industrialized nations with regards to pass-through. It is difficult to say the economies function differently because the group of developing countries has a strong overlap with the countries that are high inflation countries.²⁷ When examining the series of impulse responses for the developing and industrial country groups (not shown for space considerations) one notable feature is that the general shapes of the impulse responses are quite close. Both direction and statistical significance tend to be the same across the two samples.

Two differences are striking, though. First, supply shocks and nominal shocks are much larger in the developing countries. This does not mean their economies are different in the way that they react to shocks or in the way pass-through operates; it simply means that the shocks developing countries face are larger and the economies are potentially more unstable.²⁸ The effect of the supply shock on the nominal exchange rate in industrial countries is so weak that it has no appreciable effect for the industrial countries unlike the pooled sample or developing countries. Also, the nominal shock generates a slight, but statistically insignificant, real exchange rate depreciation for industrial countries unlike the small appreciation in developing countries. High and low inflation countries mirror this result. The importance of the supply and nominal shocks is also seen in the larger variance decomposition shares of the nominal exchange rate for developing countries (26% and 21% respectively) compared to industrialized countries (1%, 8%). (see table 3).

[INSERT TABLE 3 ABOUT HERE]

Second, looking at table 1, we see the effect of a demand shock on both consumer prices and import prices is somewhat weaker in industrialized countries. The impact is that pass-through into import prices is not as immediate in industrialized countries. Developing countries have pass-through into import prices after a demand shock of 1.00 at period 1 and .95 after a year, while industrial countries are weaker (.58, .78). In addition, pass-through into consumer prices is lower for the industrialized countries (-.08, -.03) compared to developing countries (.25, .32). Given the importance of the demand shocks and the fact that they map most closely to notional pass-through, these results are quite important. Again, it seems, though, that these results are driven by the inflation histories. High inflation and low inflation countries show a similar divide, and low

range from 5 to 39% of the variance decomposition with an average of 18%. Inflation is driven by supply and nominal shocks. Finally, roughly 30-40% of the variance of changes in import prices can be attributed to import price shocks with nominal shocks, demand shocks, and supply shocks comprising of the rest. Despite no restriction on the data, import prices do not seem to react at all to changes foreign prices identified through exchange rate changes. This is consistent with logic. If the shock is to foreign prices and the exchange rate adjusts, there is no need for an import price change.

²⁷ Chile, Colombia, Hungary, and Poland all have an average quarterly inflation rate above 3%; Greece is the only industrialized country that does. At the same time, Germany, Japan, and Switzerland are all below 1% while Singapore is the only developing country that fits that criteria. (Korea, the other developing country in the sample, falls in between as do the remaining industrial countries).

²⁸ One can see this result based on the fact that the pooled point estimate is always closer to zero than the developing country for each variables response to both supply and nominal shocks, and, in fact, it often lies closer to zero than the 95% confidence interval.

to moderate inflation developing countries like Singapore and Korea exhibit low and even negative pass-through for both import prices and consumer prices. It may be that in high inflation countries, depreciation is viewed as information that a nominal shock has taken place or is coming and hence inflation expectations shift even if there was not a nominal shock. This would generate consumer price reactions to demand driven real exchange rate movements.

We can learn more by studying the individual country responses. The shocks that drive the nominal exchange rate vary across countries. In the variance decomposition at time 5 for the nominal exchange rate (table 3), demand shocks have a range of 38 to 80% of the variance decomposition. On the other hand, nominal shocks are quite important for some countries (Chile and Finland are over 30% while many are 5% or less); foreign shocks range from 2 to 36%, supply shocks from 1% to 32% and import price shocks 1 to 15%.²⁹ Given that the pass-through ratio is different with respect to different shocks, this means that certain countries may have different measured pass-through in part because of the shocks they have faced. In addition, if the shocks change, historical measured pass-through may not be a good predictor.

Another important feature is that nominal shocks are fairly important. In particular, if one considers both nominal shocks at home and abroad, we see a range of 6 to 41% of the nominal exchange rate driven by nominal factors with an average of 24%. It is important, though, to note the source of the nominal shock. Since home nominal shocks tend to generate full pass-through and foreign almost none. In some cases (Finland) almost all of the nominal shock is from home, while in others (the US) the nominal shocks seem to be mostly from abroad.³⁰

There is not space to show all 25 impulse response functions for all 16 countries. In general, the pooled results give us a good summary of the behavior of the individual countries with the few exceptions. The important difference in the impulse response functions is the nominal exchange rates' reaction to some shocks. By and large, the nominal exchange rate appreciates with a supply shock (increase in industrial production), depreciates with a demand shock (RER depreciation), depreciates with a nominal shock, depreciates with a foreign price shock (decrease in foreign prices), and has no appreciable change after an import price shock. The pattern is slightly different with high and low inflation countries (or with industrial and developing). Some low inflation countries demonstrate almost no response, or even an appreciation of the nominal exchange rate, following a nominal shock; the effect, though, is generally quite weak. The low inflation countries as a group have a small depreciation that fades, but the variance decomposition of nominal shocks is only 3%. Germany, Austria, Denmark, and Colombia, either begin with a small appreciation or show one by time 5. This will obviously have an impact on pass-through after nominal shocks since the

²⁹ Supply shocks are far more important for developing nations with the top 5 countries (based on supply's share of the variance decomposition) all being developing countries. The pooled developing countries had a 26% share while the pooled industrial was 1%.

³⁰ The presence of countries like Mexico and Brazil, which experienced very high inflation at times, in the US trade weighted baskets generates a strong importance of foreign price shocks in the US nominal, though not necessarily real, exchange rate.

exchange rate is appreciating, not depreciating by time 5. In all cases, though, the effect is weak (with small variance decomposition) and not distinguishable from zero. The same countries are the only ones that appreciate following a supply shock. Again, though, the effect is generally fairly small.³¹

For import prices, the only major variation across countries is the import price response to demand shocks. For the pooled results, import prices and nominal exchange rates tend to move exactly together; the pass-through ratio for the pooled group is .86 at period 1 and .92 at period 5. There are six nations, though, for whom the initial reaction is very weak (a ratio of .10 or less). Such a reaction is more consistent with pricing to market or local currency pricing than all the other results suggest. In all of these cases, though, the real exchange rate share of import prices variance decomposition is below 9% (average of 3%). The countries are Finland, Greece, Hungary, Singapore, Switzerland, and the US. For the US, the reaction makes sense as many US imports are priced in dollars either because they are commodities priced in dollars or the size of the US market warrants pricing to market. For the other countries, the reasons are less clear. The reactions are weak and not statistically significant, and the low share of variance decomposition suggests that these responses make up little of the behavior of import prices.

6. Alternative specifications:

Rogers (1999) follows the advice of Faust and Leeper (1997) to do a number of robustness checks on the long run restrictions. Of particular concern are the ordering of the variables, the issue of mixing shocks together (not splitting up the shocks sufficiently), and the general validity of the long-run restrictions. One suggestion on the last point is to examine the long run responses when the short run restrictions form for the VAR is used. That is, if we restrict the short run responses, and let the long run responses go free, will the variables constrained to have no long run reaction end up moving in the long run? Importantly, since the shocks are identified differently, it is not a literal test of whether the variable will respond to the long run identified shock if unconstrained; the idea is to see if the constraints appear to match other structures. We want to examine if there is a long run response in a variable after a change in another variable. The only restrictions now are that some variables cannot affect others in the first period.³² For example, does output respond to nominal shocks in the long run if it is not constrained based on a short run restrictions VAR. As it turns out, the long run restrictions appear to match not only intuition but they match the predictions of other identification strategies. There is no example of a variance decomposition share greater than 3% for any response that has been constrained to zero by the long run restrictions, nor are any of the responses that are constrained to zero statistically significantly different from zero. In fact, the industrial production, real exchange rate, and consumer price series are all completely dominated by their own shocks with a variance decomposition share of over 95% for the supply, demand, and nominal shocks respectively. Furthermore, the

³¹ Looking at the pass-through ratios in appendix table 1, we also see negative pass-through ratios after a supply shock for Finland, Switzerland, and the UK. In these cases, the nominal exchange rate is just above zero after a supply shock, but definitely not a statistically significant appreciation.

³² I use a Choleski decomposition in the same order as variables are placed in the long run VAR.

broad story stays the same. Prices, nominal exchange rates, and import prices react with generally the same pattern to the five shocks as they do with the long run restrictions.³³

[INSERT FIGURE 4 ABOUT HERE]

Using the long run restrictions, the ordering of the variables is of concern with regards to two variables in particular. One might argue that the exchange rate regime should play a significant role in the way we model home and foreign price shocks. If a country is credibly pegged, the interest parity equation suggests that the home country must follow the foreign country's monetary policy. This calls for switching the order of home and foreign price shocks in the VAR for fixed exchange rate countries if foreign price shocks were only those in the base country. There are two reasons to reject this strategy. First is the fact that very few countries stay credibly pegged for even a few years let alone a long period of time. This suggests that in the long run, prices are still determined by home nominal shocks, which may from time to time force the exchange rate regime to break. Furthermore, since the data is multilateral, no country is actually pegging its multilateral exchange rate, it would peg to one currency. Thus, the nominal exchange rate used in the regressions will not be pegged.

If a country credibly pegged and really followed the base monetary policy perfectly, the one difference would be that shocks to CPI would not originate from the home country, but would instead be caused by shocks to the base country money supply which the home country had to follow. So, perhaps for the pegged countries, the name of the nominal shock should change to base country price shocks, with home nominal shocks being entirely driven by base country shocks. The ordering does not change as changes in the multilateral nominal exchange rate not caused by base country nominal shocks would be other (non-base) foreign price shocks. The effect of the fixed exchange rate would be to eliminate home nominal shocks altogether. The regression would not change, just the interpretation. The other difference would be that we would not expect an exchange rate reaction to nominal shocks because pegged countries are simply following the base country. This may in fact explain why Austria and Denmark show little nominal exchange rate response to price shocks; they may simply be following Germany and thus the exchange rate does not change. In addition, if enough of Germany's trade partners are pegged to it throughout the sample, we would not expect its exchange rate to change when its own prices do because its partners have to follow its nominal shocks.³⁴

As a test, I did try switching the nominal exchange rate and prices. The regression coefficients and statistics do not change because the same variables are included. Likewise, the responses of industrial

³³ See figure 4. Minor differences include a smaller p response to demand shocks, slightly negative instead of slightly positive p and pm responses to foreign price shocks, and slightly negative instead of zero response from p and s following an import price shock. The only large difference is that p , s , and pm go up after a supply shock instead of down. If the short run VAR is more apt to identify temporary output spikes and long run restrictions identify productivity advances, this disparity is logical.

³⁴ The only other country with a zero response or appreciation to the nominal exchange rate following a nominal shock is Colombia. It did not maintain an exchange rate peg during the sample.

production, real exchange rates, and import prices to supply, demand, and import price shocks do not change either. The only difference is the relative importance of changes in home nominal shocks and foreign prices. With the nominal exchange rate before prices in the regression, a permanent change in s , even if caused by a nominal shock, will be considered a foreign price shock. In practice, the nominal exchange rate variable picks up far more importance as it has basically taken over the nominal shocks. Thus, we see switching this ordering is neither necessary nor sensible.

The next concern is the commingling of shocks. Both Weber (1997) and Rogers (1999) try splitting nominal shocks in two to see if some of the importance is being lost in the way they are mixed. I try two procedures. One is to add money demand (money divided by prices) into the regressions; the other is to add money by itself. Since it is unclear whether one would want to model these as preceding or following consumer prices in the ordering, I try both ways. The results are somewhat surprising. The money demand variable plays essentially no role in any of the other variables. Even listed ahead of prices in the ordering, it never generates a share of the variance decomposition above 3% for industrial production, real exchange rates, nominal exchange rates and import prices. It is weak for consumer prices as well, with a small effect hovering near zero. It also has no effect on the pattern of the other variables. Finally, it is almost entirely determined by its own shocks (roughly 90%). Placing M/P after prices in the ordering makes it even less important to other variables.

The other option would be to include money directly. In theory, the consumer price series should identify any purely monetary shock. The concern might be that by the time prices start to rise, for the nominal shock to be identified, much of the nominal shock may have faded.³⁵ Thus, I try including money in the regression first before prices and then after prices. When listed first, the money shock picks up most of the effect previously attributed to the nominal price shock with money's share of the variance decomposition always quite a bit larger. However, the presence of money in the regression actually does not change the regressions at all. The impulse responses with respect to money and consumer price shocks always move in the same direction by the same quantity with the exception of money itself.³⁶ In that case, money reacts negatively to prices, most likely reflecting the reaction function of central banks to reduce the money stock when prices are rising too fast. In addition, nominal shocks play no more important a role in the variance decompositions after splitting in two. The share attributed to money shocks and to price shocks, when added, always equals the share attributed to home nominal shocks when they are represented by prices alone. There

³⁵ As discussed above, the pooled results do not show a hump shaped output response to nominal shocks (though many countries do). This could be because nominal shocks are identified too late. This might also explain the lack of overshooting in the results.

³⁶ The only small exception is that low inflation countries exhibit a later hump in output's response to a nominal shock. The peak is in the 4th period in response to money and in the 1st period in response to prices when included together. The peak is in the 3rd period when prices alone are used. There is still no overshooting in the results.

is never a difference of more than 3% at any horizon for any variable's response. Thus, the use of prices to proxy nominal shocks seems an appropriate one.³⁷

Finally, one could worry about price shocks that are not a result of money increases. The theory says that any long run price increase must have come from long run money increases, but one may worry about commodity price shocks as well. In the long run, excluding these should make sense because if money does not rise, the price level should not either. Still, I try including oil price shocks to see if they are a different type of price shock or a different type of supply shock. As it turns out, a variety of specifications do not seem to provide more insight. If oil prices are used in dollars and listed as the very first shock, then they never take a substantial share of any variance decomposition (the highest is 7-8% for consumer prices) nor do they seem to have any effect on other variables. On the other hand if the price of oil in domestic currency is used, then the fact that the nominal exchange rate is incorporated into the oil variable means that the oil variable will take all the impact of nominal variables. Much like switching the consumer price level and nominal exchange rate, if any variable with a nominal component precedes the nominal shock, the regression will yield odd results that are probably not very informative.

In general, the core specification seems to withstand most alternative specifications. The only ones that generate a substantial change, those that have another nominal variable in front of the nominal shock, seem misspecified. In particular, the fact that the inclusion of money in the regression along with prices in various specifications does not change the importance of nominal shocks or the general impulse responses is supportive of the core specification.

7. Conclusion:

While many macro pass-through studies ignore the fact that exchange rates and prices are both endogenous variables responding to the same shocks, this study tries to decompose the exchange rate change into different parts when ascertaining the response of prices to the exchange rates. The long-run restrictions VAR employed generates sensible impulse responses that match both theory and generally accepted stylized facts. The variance decompositions seem reasonable and match previous studies that have used slightly different methodologies. Finally, a variety of alternative specifications either do not change the results or can be ruled out on theoretical grounds. Thus, the model leaves us in a position to examine the responses of exchange rates and prices to fundamental shocks.

With the exception of the foreign price shock, import prices move in the same direction as the nominal exchange rate after each shock. This is supportive of the idea that import prices tend to be set in the producer's currency. On the other hand, import prices do not react to real exchange rate changes for some countries, notably the US. Since a majority of studies use the US to study pass-through, it is important to note that it does not have the typical response. We may be far more likely to find pricing to market in a market as

³⁷ When money is included after prices, it acts just as the M/P variable did. The reason is that money shocks would be identified as long run increases in money that did not have a long run impact on prices, in other words, a long run money demand shock.

important as the US. The finding that the type of shock is not too important for our import price pass-through ratios is consistent with the results of Campa and Goldberg (2002) who suggest that micro factors are more important than macro factors for import price pass-through.³⁸ Consumer prices, though, do not respond in the same manner to all shocks. After nominal shocks prices move more than exchange rates, generating pass-through ratios in excess of one in most countries while demand shocks have ratios of essentially zero, suggesting that high inflation environments will have a different overall measured pass-through experience than low inflation countries. This result is consistent with Taylor's recent conjecture (2000) and results by Gagnon and Ihrig (2002). Furthermore, the fact that import prices respond to certain shocks, but consumer prices do not, is consistent with the theory that consumer prices are sticky in local currency not because imports are priced in local currency but because some sort of switching takes place before the retail level. This is supportive of models along the lines of Obstfeld (2001), Engel (2002), and Bacchetta and van Wincoop (2002).

Because pass-through ratios appear different in response to different shocks, and the variance decompositions show that different countries faced different shocks over the period, the analysis suggests that historical rates of measured pass-through across countries may not be good predictors of future patterns of price and exchange rate movements as the shocks facing economies in the future may differ from historical patterns. In the discussion following his paper regarding crises at the Jackson Hole conference (Krugman (2000)), Paul Krugman said it seemed Martians had a stable price ray beamed on earth because so many countries that broke their nominal exchange rate anchors were not seeing massive increases in inflation that some might expect based on past experience. The results of this paper suggest that this is not a surprise. The bulk of the crises under discussion were not caused by sustained increases in money supplies that forced devaluations, but were instead crises of confidence and or long overdue adjustments to changes in the world economy. Given the results here, we would not expect changes motivated by these factors to generate large changes in consumer prices.

In some sense, the results seem to imply that nominal exchange rates are doing their job. They move with other nominal variables when the shock is nominal, therefore avoiding misalignments, but they also can change to adjust for real demand shocks. The fact that consumer prices do not change but import prices do when there is a real demand shock implies that devaluation in response to a real shock can have expenditure switching effects. Import prices have changed, and the devaluation is not immediately eaten up by a full economy price level increase.

The results have a variety of implications for both policy and research. By demonstrating that different shocks will generate different pass-through ratios and different impulse responses in prices and exchange rates, the empirical results highlight the fact that discussing the effect of exogenous shocks to the

³⁸ Import price pass-through is often greater than one for nominal shocks. Thus, a very high degree of nominal shocks could generate larger pass-through. Campa and Goldberg do find that very high inflation in developing countries can generate larger import price pass-through.

exchange rate on prices makes little sense since the exchange rate is in fact determined within most models. This work also has implications for the benefits and costs of exchange rate flexibility and the attractiveness of policy proposals such as dollarization. For example, if high measured pass-through in some countries is caused by a high frequency monetary shocks which could be controlled by better institutions, then there may be nothing wrong with exchange rate flexibility for those countries; the problem instead may be the domestic institutions that control monetary policy. Making policy decisions based on historical measured pass-through rates without considering the changing macro-policy environment could be a mistake.

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Appendix I. An Illustrative Model

We begin with a simple aggregate demand equation, money demand equation, interest parity equation, import price setting process, and definition of the real exchange rate, where y_t^d is demand determined output, y_t^s is supply determined output, s_t is the nominal exchange rate, p_t is the domestic price level, p_t^* is foreign price level, rd_t is the relative world demand for home and foreign goods,³⁹ m_t is the money supply, i_t is the nominal interest rate, q_t is the real exchange rate, pm_t is the import price index, cx_t^* is the cost of foreign exports, N_t is the markup on imports, All variables (except interest rates) are in natural logs.

$$y_t^d = \alpha(s_t - p_t + p_t^*) - \beta(i_t - E_t(p_{t+1} - p_t)) + rd_t \quad (6)$$

$$m_t - p_t = y_t - \lambda i_t \quad (7)$$

$$i_t = i_t^* + E_t(s_{t+1} - s_t) \quad 40 \quad (8)$$

$$q_t = s_t + p_t^* - p_t \quad (9)$$

$$pm_t = (s_t + cx_t^*)N_t \quad 41 \quad (10)$$

Added to this are the stochastic processes that determine some of the variables. The supply determined path of output is y_t^s , and z is a supply shock. A world wide shock to relative demand for home products versus foreign products is called a .⁴² A shock to the domestic money supply is v . A shock to the foreign price level is u . I assume that the markup on foreign goods is determined by a shock, c , to the markup as well as by changes in the real exchange rate.⁴³ These shocks are orthogonal to one another and when the model is specified in differences, they are all serially uncorrelated.

$$y_t^s = y_{t-1}^s + z_t \quad (11)$$

$$rd_t = rd_{t-1} + a_t \quad (12)$$

$$m_t = m_{t-1} + v_t \quad (13)$$

$$p_t^* = p_{t-1}^* + u_t \quad (14)$$

$$N_t = N_{t-1} + f(\Delta q_t, E_t(\Delta q_{t+i})) + c_t \quad (15)$$

³⁹ While it is expressed in the model as the relative demand for goods, we may also assume that relative demand for assets could drive the real exchange rate as well.

⁴⁰ One may think that in a fixed exchange rate environment, it is the exchanger rate commitment that determines interest rate movements. The way such a regime would affect this model is discussed in Section VI.

⁴¹ In levels, $Pm = (S CX^*)^N$. N is the markup on the foreign cost.

⁴² As discussed, the shocks to the real exchange rate could also include changes in tastes for financial assets.

⁴³ The change in the real exchange rate affects the markup through the presence of import-competing goods and the way in which exporters adjust their prices due to local competition. If domestic prices and the exchange rate rise together, import prices will simply rise along with them due to the presence of the exchange rate in equation 10). If however, there is a real exchange rate depreciation, exporters may want to change markups to hold onto market share. Future changes in the real exchange rate matter as the degree to which margins are squeezed may depend on whether the change is seen as permanent or not. It may be, though, that exporters do not worry about such considerations at the import price level and that we only see such effects at the consumer level. See Bacchetta and van Wincoop (2002).

In the long run, output is supply determined and prices make all necessary adjustments to achieve equilibrium. To explore the long run, we may assume flexible prices, so there is full adjustment at time t to any shock in period t . Thus, $p_t = E_t[p_{t+1}]$, as any change to prices is made contemporaneously. This means the expected difference between p_t and p_{t+1} caused by any shock will be zero. In addition, I assume that the real interest rate is constant and normalize it to zero. This means the long run interest rate is zero, and the interest rate drops out of the output and price equations. These assumptions generate the following long run equations for the variables:

$$y = y^s \quad (16)$$

$$q = (y - rd) / \alpha \quad (17)$$

$$p = m - y \quad (18)$$

$$s = (y - rd) / \alpha + p - p^* \text{ [from 13) and 4)]} \quad (19)$$

$$pm = (s + cx^*)N \quad (20)$$

Adding to these equilibrium equations the stochastic shock equations, we have the following derivations of each variable in the long run.

$$y_t = y_{t-1} + z_t \quad (21)$$

$$q_t = (y_t - rd_t) / \alpha \text{ which leads to } q_t = (y_{t-1} + z_t - rd_{t-1} - a_t) / \alpha \quad (22)$$

$$p_t = m_{t-1} + v_t - (y_{t-1} + z_t) \quad (23)$$

$$s_t = [(y_{t-1} + z_t - rd_{t-1} - a_t) / \alpha] + [m_{t-1} + v_t - y_{t-1} + z_t] - [p^*_{t-1} + u_t] \quad (24)$$

(where the first term in brackets is q , the second term is p , and the third term is p^*)

Finally, beginning with 16) and substituting in for s and N as well as allowing cx^* to be affected by the same shocks hitting p^* , we arrive at

$$pm_t = [([(y_{t-1} + z_t - rd_{t-1} - a_t) / \alpha] + [m_{t-1} + v_t - y_{t-1} + z_t] - [p^*_{t-1} + u_t])(cx^*_{t-1} + u_t)](N_{t-1} + f((y_{t-1} + z_t - rd_{t-1} - a_t) / \alpha) + c_t) \quad (25)$$

Thus we see that the long run restrictions described earlier in the paper come from this simple setup. Only z affects y in the long run. Only z and a affect q in the long run. Only v and z affect p in the long run.⁴⁴ All these shocks (z, v, a) can affect the exchange rate; in addition, shocks to foreign prices (u) will cause the nominal exchange rate to change. Finally, because the exchange rate can react to all these shocks in the long run, import prices may respond to all of them as well as c , the shock to markups.

In the short run, if prices are sticky, the economy does not quickly reach the flexible price supply determined output after a shock. Instead, output is demand determined, and p_t does not necessarily equal p_{t+1} .

⁴⁴ This is, in fact, more restrictive than we need to use the Blanchard Quah methodology. Under our method, shocks to relative demand are not restricted from altering prices. Clarida and Gali generate shocks to relative demand which alter prices even under the flexible price solution by defining a more complex time process for relative demand shocks.

We also assume that the economy does not adjust to push p to the long run equilibrium immediately, and thus, import prices may affect the domestic price level. More formally I will assume a combination of sticky domestic prices and import prices determine the short run price level. In the long run, prices on domestic goods and import quantities and prices adjust so that the overall price level is determined by the money demand equation. Let p_t^d be the price of domestic goods, $p_t^{d,e}$ be the flexible market clearing price, and j be the short run import price share of the CPI.⁴⁵ We write the short run prices as:

$$p_t^d - p_{t-1}^d = \theta(y_{t-1}^d - y_{t-1}^s) + E_{t-1}(p_t^{d,e} - p_{t-1}^{d,e}) \quad (26)$$

$$p_t = j(p_t^d) + (1-j)pm_t \quad (27)$$

We see that if there is a shock such that prices will continue to adjust after time t , then p_t does not equal p_{t+1} . The equilibrium price is not reached immediately because some prices in the economy are set the period before the shock. That is, by 26) any shock that has changed p^d to a value different from the one expected a period before will generate changes in y since $p_{t+1} - p_t$ is in equation 6). In addition, since the import share will not adjust immediately, a change in import prices can temporarily have an impact on the overall domestic price level. Over time, import share and domestic prices adjust so that price is still determined by $m - y$ in the long run.

All shocks, then, those to relative demand, domestic prices, nominal exchange rates, or import prices can change the demand determined level of y . In addition, since y is a factor in all other variables' determination, that alone guarantees that all variables are affected by all other variables in the short run. All shocks can have contemporaneous effects on all variables.

Appendix II. Description of Blanchard Quah methodology

To enforce these restrictions, we follow the methodology described below where k is the vector of all our dependent variables [ordered y, q, p, s, pm] and e is the vector of our shocks [ordered z, a, v, u, c]. We begin with the equation:⁴⁶

$$\Delta k = C_0 e_t + C_1 e_{t-1} + C_2 e_{t-2}, \dots \quad (28)$$

We estimate the equation to get the following

$$\Delta k = w_t + R_1 w_{t-1} + R_2 w_{t-2}, \dots \quad (29)$$

Note that R_0 is by definition being set to the identity matrix.

⁴⁵ j can be less than the share of imports in the economy if import prices are not passed on to consumer prices due to competition with domestic prices. Again, see Obstfeld (2001) and Bacchetta and van Wincoop (2002).

⁴⁶ This description relies on Blanchard and Quah (1989), Clarida and Gali (1994), Lee and Chinn (1998) and Weber (1997).

We assume that there exists a non-singular matrix S that lets us recover e_t from w_t , that is that $w_t = Se_t$. We see that S in fact = C_0 . This means:

$$w_t = C_0 e_t \quad (30)$$

and at each lag, $C_1 = R_1 S$, etc. We see then that $C(L) = R(L)S$. The sum of these coefficients will be called $C(1)$ and $R(1)$. We see from the above statements, then, that $C(1) = R(1)C_0$, or

$$R(1) = C(1)C_0^{-1} \quad (31)$$

At the same time, we can normalize e to unit variance and then say that we estimate the covariance matrix of our errors as Σ .

Thus, $\Sigma = E(w w')$. In which case we know that

$$\Sigma = C_0 C_0' \quad (32)$$

C_0 , though, is still not identified, and we need to add more restrictions. Here is where we add our long-run restrictions developed in the previous section. The long run restrictions generate a lower triangular $C(1)$ matrix. We know from 31) that

$$C_0 = R(1)^{-1} C(1) \quad (33)$$

If we create the matrix:

$$R(1)\Sigma R(1)' = HH' \quad (34)$$

Then we can see this is equal to $C(1)C_0^{-1}C_0C_0'(C_0')^{-1}C(1)' = C(1)C(1)' = HH'$. Thus, the lower triangular Choleski decomposition of the matrix from 34) is in fact $C(1)$.

We now can identify C_0 from the original equation we tested. We are able to calculate our lower triangular matrix $C(1)$, which represents the summation of all impacts from the shocks, from the matrix $R(1)\Sigma R(1)'$, from there, we use 31) to generate C_0 . That is:

$$C_0 = [R(1)^{-1}]chol[R(1)\Sigma R(1)'] \quad (35)$$

One important thing to notice is that the C_0 matrix is not lower triangular, nor for that matter is C_1, C_2, \dots . It is the long run effect, the sum of these coefficients, that is lower triangular. We are making no assumptions about the short run behavior of the variables, we are only making assumptions about the long run behavior. Once we have the C_0 matrix, we are able to identify the shocks and examine impulse responses and variance decompositions of our variables with regards to these shocks.

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Figure 1: Pooled Sample impulse responses to supply and demand shocks

center line is point estimate, outer lines are 5% and 95% confidence intervals

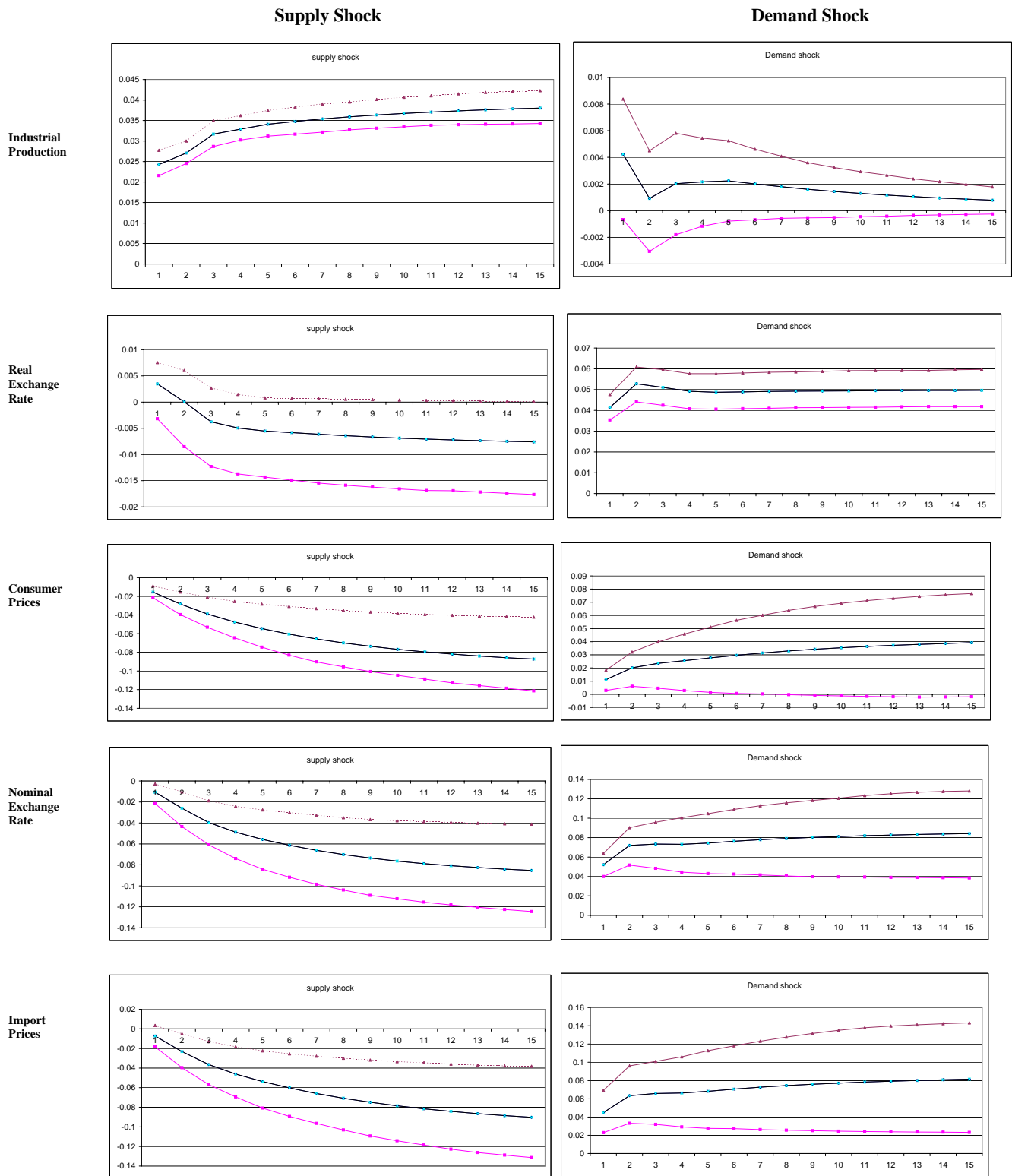


Figure 2: Pooled Sample impulse responses to nominal, foreign, and import price shocks

center line is point estimate, outer lines are 5% and 95% confidence intervals

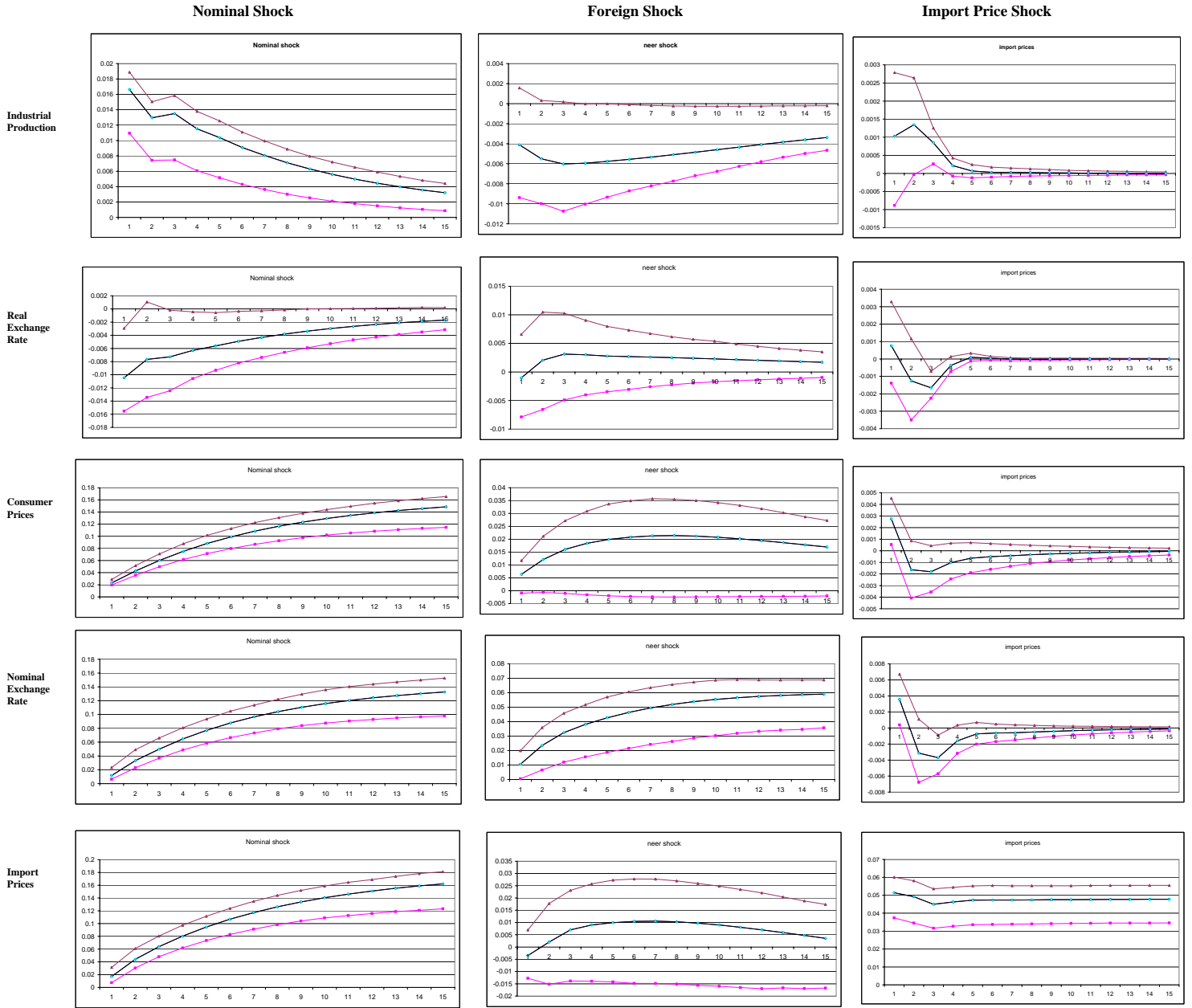


Figure 3 Pooled Sample responses of p, s, and pm to various shocks

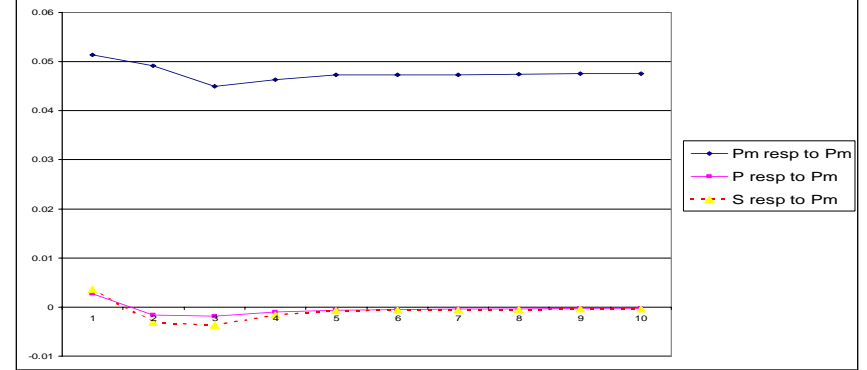
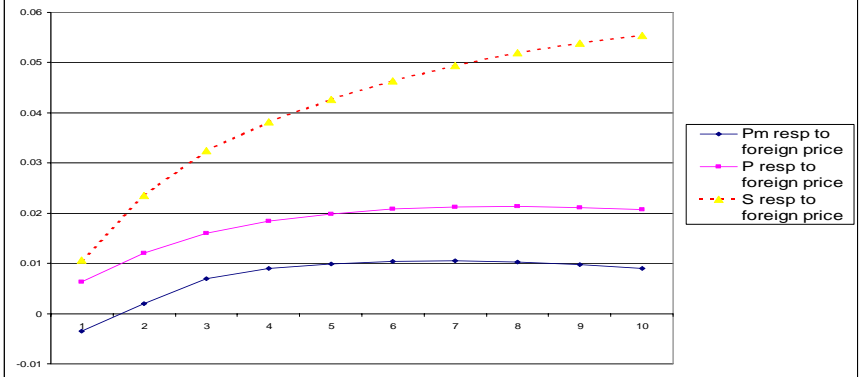
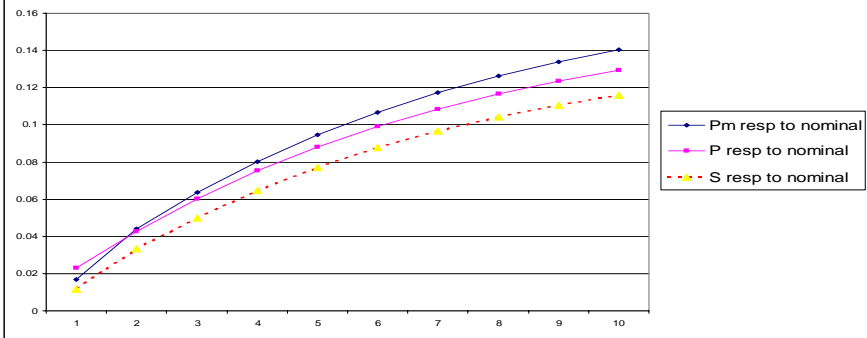
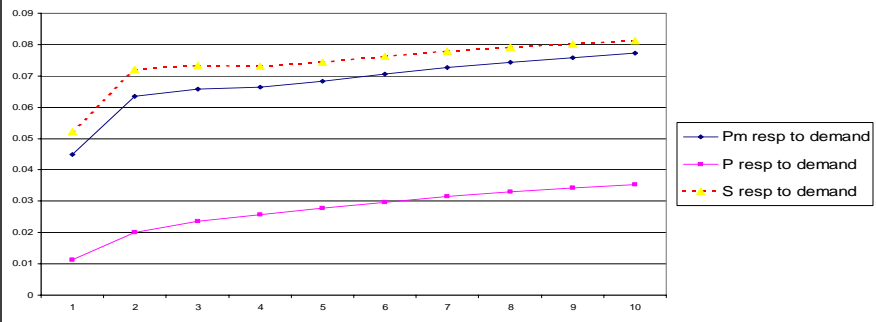
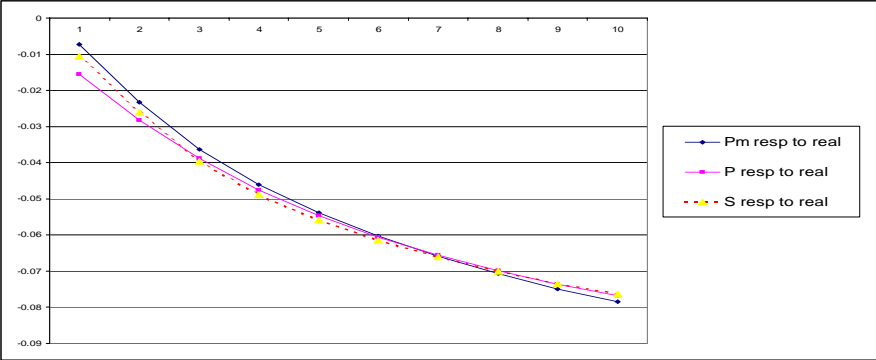


Figure 4: Responses of p, s, pm to various shocks using short-run restrictions

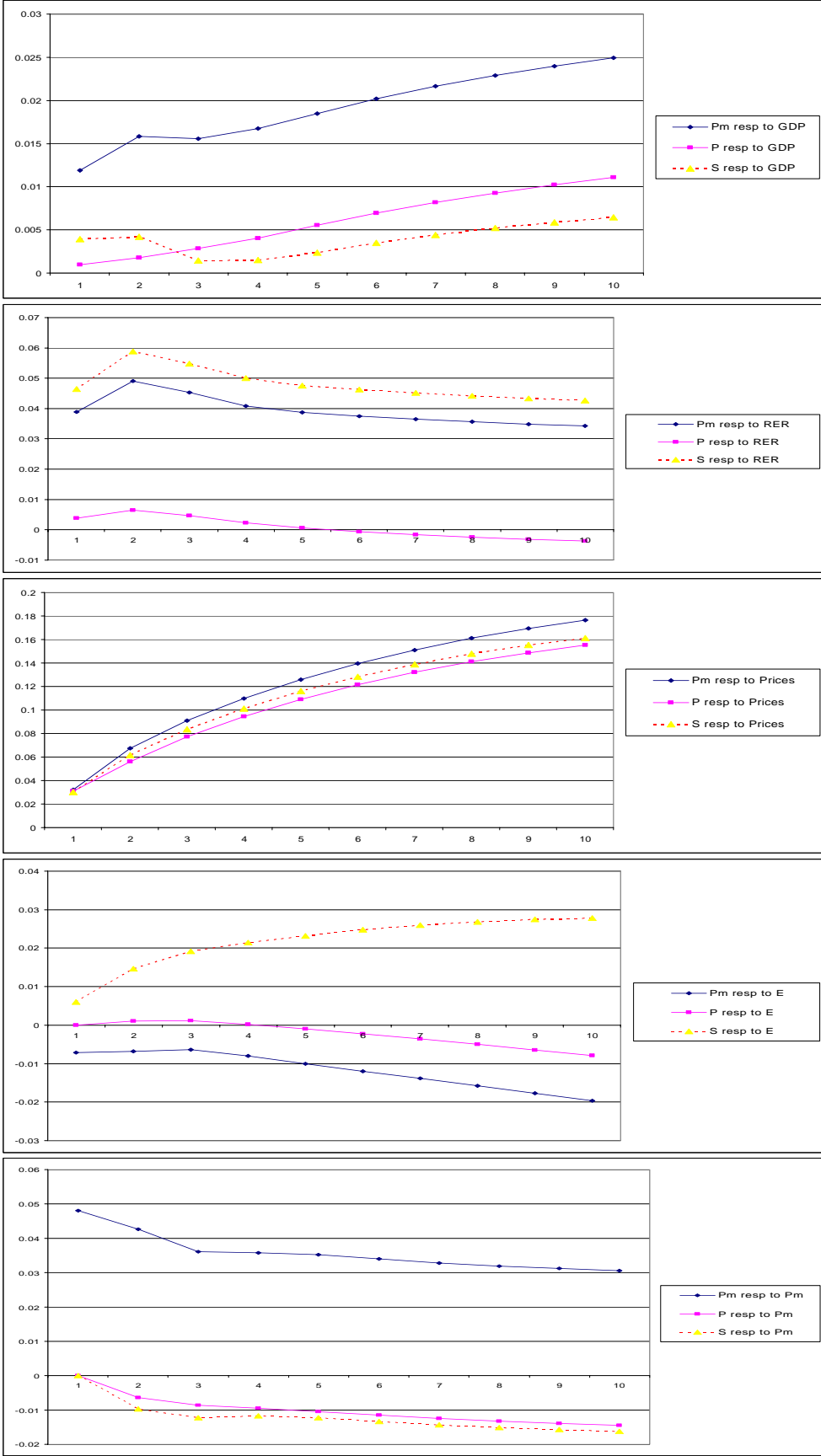


Table 1. “Pass-through” ratios following shocks
(reaction of price / reaction of nominal exchange rate)

		Supply		Demand		Nominal		Foreign		Import Price	
Country	time period	cpi	import price	cpi	import price	Cpi	import price	cpi	import price	cpi	import price
Pooled	period 1	1.46	0.69	0.21	0.86	1.97	1.45	0.60	-0.33	0.77	14.42
	5%	0.88	-0.83	0.07	0.54	1.16	0.65	-0.05	-3.30	0.18	5.94
	95%	3.17	1.26	0.30	1.15	3.38	2.46	1.52	0.68	1.79	37.75
	period 5	0.98	0.96	0.37	0.92	1.14	1.23	0.47	0.23	0.87	-64.62
	5%	0.82	0.69	0.03	0.59	1.05	1.04	-0.05	-0.76	0.00	-301.76
	95%	1.17	1.13	0.51	1.16	1.27	1.41	0.61	0.51	1.98	252.42
Industrial	period 1	-6.05	-8.10	-0.08	0.58	0.95	1.68	0.50	-0.12	1.16	-22.23
	period 5	3.13	4.10	-0.03	0.78	1.54	2.83	0.38	-0.21	0.74	-45.82
Developing	period 1	1.14	0.40	0.25	1.00	1.57	1.61	0.55	-1.17	0.60	36.70
	period 5	0.94	0.94	0.32	0.95	1.07	1.23	0.34	0.13	1.00	-17.71
High Inflation	period 1	1.17	-0.06	0.30	1.07	2.12	2.05	-0.01	0.65	2.81	102.83
	period 5	0.86	0.82	0.43	1.04	1.11	1.26	-0.01	0.14	0.98	-24.19
Low Inflation	period 1	-.058	-1.42	-0.08	0.74	0.96	3.41	0.38	0.55	.049	-4.92
	period 5	-1.41	-1.26	-0.03	1.03	4.92	14.78	0.38	0.39	4.32	-200.0

note: each column shows the response of a price index to a shock divided by the response of the exchange rate to a shock. The pooled sample shows 5 and 95% confidence intervals. Period 1 is the contemporaneous reaction, period 5 is the reaction after 1 year.

Table 2. Variance Decompositions for pooled data

%change in Industrial Production

time	supply	demand	nominal	foreign	import price
1	65.4	2.0	30.6	1.9	.1
5	64.2	3.1	30.5	2.0	.2
20	63.8	3.1	30.9	2.0	.2

%change in Real Exchange Rate

1	.7	93.3	5.9	.1	.0
5	2.0	91.3	5.8	.6	.3
20	2.0	91.1	5.9	.6	.3

%change in CPI

1	25.3	13.3	56.4	4.3	.8
5	24.2	8.6	62.0	3.7	1.1
20	24.0	7.5	64.3	3.3	.9

%change in Nominal Exchange Rates

1	3.6	87.9	4.4	3.6	0.4
5	12.1	56.6	22.7	7.5	1.1
20	12.8	51.6	27.0	7.4	1.0

%change in Import Prices

1	1.1	40.2	5.8	.2	52.7
5	8.3	31.1	24.7	.9	35.0
20	9.5	28.5	29.2	1.0	34.1

Table 3. Variance Decomposition of %change in Nominal Exchange Rates
(at time 5)

Country	Supply	Demand	Nominal	Foreign	Import Price	Sum of home and foreign price shocks
Pooled	12	57	23	7	1	30
Industrial	1	79	8	12	1	20
Developing	26	48	21	3	2	24
High Inflation	28	49	20	2	1	22
Low Inflation	3	78	3	14	2	17
Australia	4	72	12	7	5	19
Austria	3	64	12	18	3	30
Chile	31	44	18	2	5	20
Colombia	6	80	1	5	8	6
Denmark	6	77	5	11	1	16
Finland	1	55	36	5	3	41
Germany	10	48	17	22	3	39
Greece	2	50	3	36	9	39
Hungary	12	71	11	2	4	13
Japan	8	74	2	15	1	17
Korea	19	38	4	24	15	28
Poland	27	52	15	5	2	20
Singapore	32	45	5	17	1	22
Switzerland	2	58	31	2	7	33
UK	1	73	6	17	4	23
US	5	73	3	19	1	22

Appendix Table 1: “Pass-through” ratios following shocks
(reaction of price / reaction of nominal exchange rate)

		Supply		Demand		Nominal		Foreign		Import Price	
Country	time period	cpi	import price	cpi	import price	Cpi	import price	cpi	import price	cpi	import price
Australia	period 1	1.83	2.59	-0.02	0.66	0.40	0.95	0.49	-0.15	0.39	-17.00
	period 5	0.88	2.10	-0.10	0.51	2.57	4.33	0.33	-0.48	-1.06	-31.42
Austria	period 1	-1.13	-2.56	-0.13	0.81	0.72	3.15	0.83	-0.20	2.83	116.63
	period 5	-1.36	-1.34	-0.19	0.34	-6.57	-22.61	0.55	-0.45	-1.47	100.61
Chile	period 1	0.84	0.05	0.35	1.35	-0.27	0.61	-0.17	0.40	2.31	17.34
	period 5	0.76	0.93	0.45	1.21	2.21	2.05	-0.23	0.10	0.73	13.90
Colombia	period 1	-0.41	0.43	-0.05	0.33	13.41	8.81	3.26	-1.31	0.17	-0.78
	period 5	-0.01	0.82	-0.06	0.34	-2.53	-2.77	0.24	-0.46	0.61	-2.66
Denmark	period 1	-3.22	-8.04	0.00	0.93	-1.71	-2.96	0.99	0.11	-3.28	16.50
	period 5	-3.31	-6.85	0.36	1.43	-2.68	-5.92	0.64	0.44	1.41	-23.65
Finland	period 1	-2.32	-3.71	-0.14	-0.02	0.03	1.02	0.71	-0.69	-0.25	9.65
	period 5	-56.11	-51.48	-0.22	-0.24	0.54	3.01	0.79	-1.31	-1.19	39.45
Germany	period 1	-0.57	-1.38	0.04	1.36	-1.05	-1.57	0.32	0.66	0.28	-4.06
	period 5	-0.99	-2.76	0.16	2.34	-0.27	-1.34	0.37	0.45	0.26	-25.03
Greece	period 1	2.57	0.81	-0.21	0.10	1.78	2.43	0.25	0.56	0.00	2.88
	period 5	1.62	0.69	-0.25	-0.25	3.00	4.28	0.70	0.78	2.28	-94.96
Hungary	period 1	2.49	0.53	0.12	0.01	0.94	0.47	-3.18	1.36	6.64	-44.96
	period 5	1.48	0.50	-0.08	-0.18	0.62	0.79	-0.58	-0.30	3.63	-31.19
Japan	period 1	0.37	1.75	-0.05	0.88	20.99	46.17	0.01	0.49	-0.03	-8.04
	period 5	0.53	1.35	0.06	1.47	2.59	6.28	0.10	0.37	0.88	31.07
Korea	period 1	0.14	0.96	-0.15	0.27	0.77	3.75	0.43	0.58	-0.11	1.50
	period 5	0.09	0.30	-0.21	0.10	2.40	5.54	0.77	-0.05	1.56	-23.14
Poland	period 1	2.22	0.43	0.61	0.62	0.54	3.02	-0.54	2.98	0.70	-3.02
	period 5	1.12	0.89	0.56	0.99	0.84	1.85	0.94	0.79	0.99	43.07
Singapore	period 1	-0.13	0.07	-0.56	-0.25	1.06	4.81	0.71	0.10	3.68	-61.57
	period 5	-0.02	1.43	-0.50	-0.24	16.58	31.41	0.62	-1.21	2.97	1048.3
Switzerland	period 1	-4.50	-10.27	-0.02	0.08	0.17	0.96	0.87	-0.30	0.41	-1.07
	period 5	-1.43	-2.64	-0.05	0.03	0.69	3.11	1.06	-1.35	-1.45	20.10
UK	period 1	-2.88	-5.75	-0.14	0.44	0.44	1.27	0.44	-0.27	0.22	2.43
	period 5	-3.93	-6.85	-0.13	0.90	1.82	3.69	0.63	-0.66	2.10	-40.74
US	period 1	0.51	2.58	-0.05	0.09	0.96	3.87	-0.02	0.04	1.33	-11.74
	period 5	1.84	6.07	-0.03	0.31	1.18	4.05	0.00	-0.18	-2.33	77.04