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Exchange Rate Pass-through in Armenia

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Abstract

In this paper we develop a semi-structural macroeconomic model to estimate the Exchange Rate Pass-through in Armenia at the hand of Bayesian estimations. Apparently, the pass-through both to import prices and core inflation is somewhat lower than the average results for comparable emerging economies appearing in the pass-through literature. The approach of calculating time-varying pass-through rates was also taken to discover key factors causing shifts over time. The macroeconomic view of exchange rate pass-through incompleteness especially the monetary policy credibility factor clears out to play a significant role.

JEL classification: F31, E31, E37, C11

Keywords: Purchasing Power, Taylor Rule, Risk Premia, Exchange Rates, Exchange Rate Pass-through, Output Inflation, Bayesian Analysis, Econometric Modeling, Simulation

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1 Introduction

Effusing from the open economy model framework, exchange rate pass-through is significant for both monetary policy analysis and decision making. In a wide range of literature it is mainly defined as either the exchange rate pass-through (ERPT) to import prices or to domestic prices. As mentioned above proper estimations of the latter are of importance, so are the reasons causing it. Therefore for better policy conduction purposes in this paper we attempt to estimate the Exchange Rate pass-through for Armenia coming from both direct and indirect channels including the demand side factors and mark-up changes. Below we review the general thoughts and theories appeared in the literature observing ERPT.

Literature Review

Originally the assumption of a complete ERPT was coming from the Law of One Price. However, as it is commonly known, the Law of One Price does not hold and hence leads to an incomplete pass-through. From the incompleteness aspect the viewpoints of economists differ. Some of them attribute it to microeconomic factors inferring from the Pricing to Market theory. Differently, the rest considers it as a cause of macroeconomic factors such as low inflationary environment generated from the price stickiness assumption.

Particularly, alluding to some evidence occurred in the countries like Sweden, UK, US, Brazil and so on, it is demonstrated in Taylor's paper of 2000 that low inflationary environment observed in some countries may itself have reduced the measured pass-through or pricing power. His staggered price model, where pricing decisions are optimally made in a monopolistically competitive environment holding rational expectations assumption, obtains that for a firm deciding on how much to adjust its price. Low inflation may be associated with less persistent changes in costs and the prices of other firms in the economy. And as a result if prices are set for several periods in advance, then the lower persistence will consequence in smaller pass-through. However, the process can be reversed again when higher inflation scope is repeated. Takhtamanova (2008) observes similar outcomes.

Choudhri and Hakura (2001) find strong evidence that the relation between the pass-through and the average inflation rate is positive and significant across inflation regimes compared between the sample countries during different periods. The implication is that the dependence of the ERPT on the inflation regime should be taken into account in designing monetary policy rules. It would be easier for a monetary authority to target a low inflation rate after the appropriate credibility is established. Devereux and Yetman (2002) come to a similar conclusion, that price stickiness does matter for the incompleteness in the exchange rate pass-through to prices.

Originating from Krugman (1986) a wide range of papers discuss partial pass-through as a result of microeconomic factors. In his paper Krugman constructs a few models explaining the causes of the Pricing to Market phenomenon,

which are applicable in the case of pass-through incompleteness too. Goldberg and Knetter (1996) suggest that exchange rate changes and the pass-through appear to depend on microeconomic factors such as mark-ups and marginal costs, demand elasticities, the "largeness" of the importer. They view national markets as segmented rather than being aggregated and conclude that third level price discrimination in such markets creates the incomplete exchange rate pass-through. Campa and Goldberg (2002) try to find out if micro or macro factors generate the pass-through to import prices. They estimate an empirical model for OECD countries deriving for ERPT elasticities and conduct a range of structural tests and infer that the partial pass-through is a common phenomenon, particularly among heterogeneous products. Estimation of a second-stage horse race regression for both micro and macro factors demonstrates that the microeconomic variables explain the most part of the pass-through, but the macro variables cannot be jointly rejected.

Abundant series of research find out that the amount of the pass-through alters across time. Particularly, Jasova, Moessner and Takats (2016) observe the pass-through for both emerging and advanced economies and deduce that it has changed since the financial crisis. Moreover, both in short and long run it decreased in emerging economies related to the decline in inflation. On the other hand, it remained stable in advanced economies at a lower level than in emerging economies. They suggest that the generally low levels today imply that usually the central banks should "fear" less the "floating" of their pass-through exchange rates and that they hint about the weakening exchange rate channel of monetary policy.

Forbes (2018) illustrates the pass-through issue from a relatively different point of view referring that the shocks generating exchange rate fluctuations matter and are of immense significance. The latter inference comes from the fact that any of the underlying shocks might create movements of the prices as well, if it is able to bring about some variations at least in one of the price-setting relevant components like markups and marginal costs other than the ones regarding exchange rate vacillations.

Moving forward, we represent the general theoretical concepts in the next chapter. After having a total view of the outstanding notions present in the theory, and in order to examine pass-through in Armenia we construct a semi-structural model in the third chapter, calibrate it according to the theory, then make several manipulations in the direction of a VAR model further applying a certain methodology to convert it to a S-VAR model and exerting Bayesian analysis in the interest of interpreting the appropriate impulse-response functions in the following chapter, and next discuss the results. Conclusions is represented at the end preceding the References and Appendix chapters where some technical test results and figures referred to the estimation can be found.

2 Exchange Rate Pass-Through: Theory and Evidence

2.1 Theoretical Framework

Theoretical framework of our model is established on the widely expanded view of pass-through incompleteness. According to which complete pass-through is unattainable because of tariffs and transportation costs. If the Law of One Price (LoOP) held, the pass-through would be complete.

$$P = P^0$$

Where denotes the exchange rate and P^0 is the price of the good in foreign currency while P is the price of the same good inside the country. However, because the LoOP does not perform in practice[1]

$$P = P^0 + tariffs + transportationcosts$$

As it was shortly introduced in the literature review, two major approaches of pass-through exist: the microeconomic view and the macroeconomic concept. The first one mainly concentrates on demand elasticities, marginal costs, mark-ups. Generally, the Pricing to Market theory developed by Krugman in 1980s is a way to explain the pass-through incompleteness from the microeconomic point of view as it attempts to find explanations for the bias from the Law of one price. The range of the reasons includes excessive demand share of the importer in the total excessive demand, incomplete competition forms, marketing and other infrastructure costs, slow demand adjustments and some technical facts like demand curve shape. He literally defines the PTM as the phenonmenon of foreign firms maintaining or even increasing their export prices to the US when the dollar rises. In addition Goldberg and Knetter (1996) point out market segmentation as a reason of incomplete pass-through. Observing deeply, their paper gives the impression of an adjusted PTM theory as their hypothesis of market segmentation coming from the third degree price discrimination nets the transportation and border costs. They define the segmentation as a lack of integration. Martson (1989) discusses the PTM theory with the help of a model where he states the important role of constancy of the marginal costs as well as demand elasticities in the context of pass-through completeness. In addition he argues that exchange rate depreciation can change the domestic price, but only if the marginal cost increases or decreases with output. In the case of varying mark-ups the pass-through is incomplete not depending on the form of the marginal costs' curves. Price stickiness is also a factor causing pricing to market in the case when the goods are differentiated and the price setter decides the export price in foreign currency based on his expectations. Yet we have to pay attention to the fact that pricing to market and exchange rate

[1] Although there are some papers which try to prove that the Law of One Price holds, the general view according to majority of the existing papers is that it does not hold in practice.

incomplete pass-through while intersecting in a wide range of aspects are not the same. Pricing to market concentrates on the export and domestic price ratio (export-domestic price margin) and the elasticity of this ratio with respect to the exchange rate change. Meanwhile, exchange rate pass-through is only about the export (import) price elasticity with respect to the alteration in exchange rate. This latter one is an important point worth of mentioning.
The macroeconomic approach is established around sticky prices, inflationary environment hence monetary policy credibility as well as exchange rate and inflation volatility. Taylor was the pioneer by his staggered price model to lead the discussion towards the macro approach. The claim is that a firm decides to hold the same price of the product if it believes in monetary policy credibility, as the inflation will be low and the firms' marginal costs will not grow way too far. But when the monetary policy is not stable and inflation is high, the firms will change the prices at once. Furthermore, Devereux and Yetman (2002) state that there is a non-linear relationship between the estimated pass-through coefficients and inflation or exchange rate volatility. They construct a menu cost model to demonstrate that the pass-through is determined by the monetary policy regime. In the model they show that price stickiness which causes the incomplete pass-through depends on the monetary policy credibility. As inflation rises, pass-through rises too just in declining rates. In addition some empirical research[2] shows that the pass-through coefficients are low in low inflation countries compared to the moderate inflation economies and the ERPT in these countries is less compared to high inflation ones. Meanwhile, for the countries which have had a few inflation regimes pass-through was less during moderate inflation regimes compared to high inflation periods inside those countries.

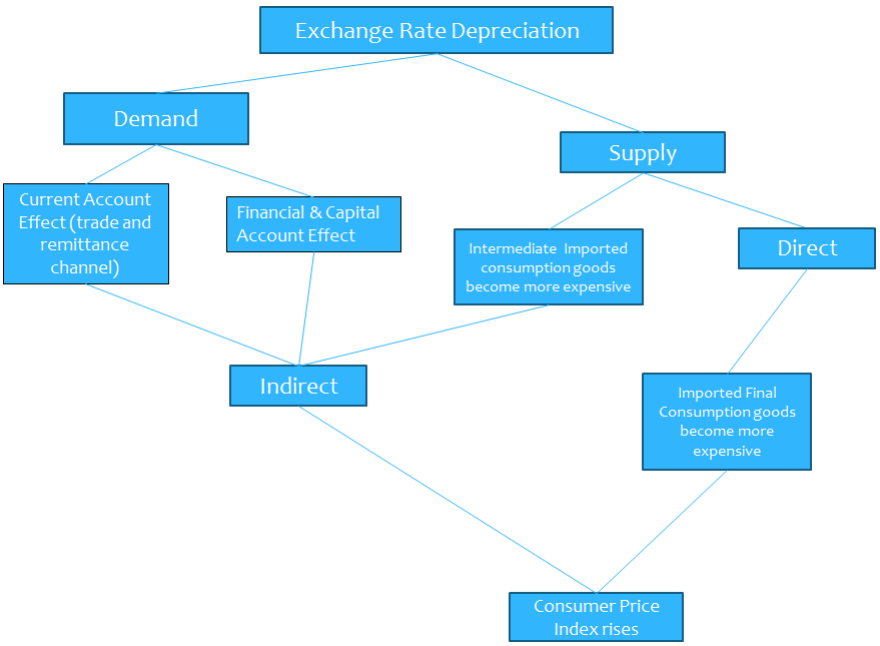
Moreover, the currency in which producer decides to set its price is also of great importance. Specifically local currency pricing principle is an equivalent of 0 pass-through as it is considered that the producer sets the price in the export destination country's currency hence absorbing the currency fluctuation risks. The case of the producer currency pricing is supposed to be par to the complete pass-through as the exchange rate fluctuation risk is now an additional cost or benefit for the buyers, and adds up to the price pushing it up or down.

The fact that a long range of factors and shocks can cause exchange rate shifts is thoroughly discussed by Forbes. She affirms and empirically shows that the ERPT is different when the shocks causing exchange rate alterations differ. The explanation comes from the following formula. $p = \quad + mc + mkup$. While some kind of shock pushes the exchange rate up or down it also might vary mark-ups and/or marginal costs, hence the ERPT of different shocks underlying in the base of the exchange rate fluctuations will be dissimilar.

To summarize the general theory directions, we define the concepts of intermediate importers and direct importers. The intermediate importers are the ones whose marginal costs in local currency have a significant share in total marginal costs, because the goods they imported enter the production process

[2] Choudhri and Hakura 2001, Devereux and Yetman 2002

as intermediate goods. The direct importers, on the other side, do not possess such marginal costs or the costs have a somewhat small share. As far as we are concerned, the intermediate importers take the inflationary environment into account, but for the direct importers this cannot really hold as most part of the costs are formed in importing country currency. The belief is that other factors can loosen the pass-through like demand elasticity changes, market share changes caused by competition. However, in general direct import prices can contain asymmetric effects. Furthermore, our purpose in this paper is to gain appropriate explanations for the pass-through incompleteness phenomenon and establish a model which will make a good sense from the viewpoint of giving an applicable estimation of the pass-through coefficient in Armenia instead of checking the validity of the theories discussed above. The figure below completes the overall picture of our model framework.



2.2 ERPT Measures

Different measures of exchange rate pass-through are suggested in the literature. One of them is simply the elasticity approach derived from the micro foundations, which is represented by the following equation.

$$\gamma = \frac{\dot{P}_t^{m,j} / P_t^{m,j}}{\dot{E}_t / E_t}$$

Where, P is the import price to the j-th country, E is the exchange rate and the dotted variables denote percentage change. This is supposed to be the short-run pass-through elasticity. To obtain the long-run coefficient, we simply need to sum up the elasticity coefficients of all the lagged values. The next famous measure technique is the cumulative approach, which is considered to be a measure of long run pass-through only and mostly appears in VAR estimation literature. It can be described in the following formula.

$$PT_{t,t+i} = \frac{P_{t,t+i}}{E_{t,t+i}}$$

Where, $PT_{t;t+i}$ is the cumulative exchange rate pass-through, $P_{t;t+i}$ is the cumulative response of prices to an exchange rate shock identified in some manner, and $E_{t;t+i}$ is the cumulative response of exchange rate to its own shock. The third distinguished approach is described as an cumulative response of the price to an exchange rate shock per unit exchange rate shock in the period of the latter's occurrence represented by

$$PT_{t,t+i} = \frac{P_{t,t+i}}{E_0} \quad .$$

The first method of measurement can not be adopted appropriately as it mainly is adopted in papers conducting regression estimations. Because of the shock identification techniques used, it is desired to apply one of the remaining two techniques. But later we use this approach to decompose the final result into direct and indirect pass-through. Although, there is an argument that the second approach is not the pure pass-through itself as it contains calculations of dynamic responses, which, on turn will be influenced by other shocks, we anyway believe, that it does demonstrate a good measure of long-time pass-through i.e. the final effect that the exchange rate has on the prices after policy and non-policy adjustments. We do not consider the use of the third approach, as supposedly, it is not a good measure of dynamic responses. And by the same argument, which was against the second approach, the price response is dynamic and it thus is a result of different adjustments happening during i periods of time. For the reasons enumerated above we use the second approach in this paper and with the help of the first approach we identify initial pass-through.

3 ERPT in Armenia

3.1 Stylized Facts

Below we are demonstrating some stylized facts typical to the Armenian economy, which were also guidelines for the data-choosing process. The broad outlook is the following. Monetary policy authority has changed its strategy in 2006

to conduct with the inflation targeting regime. The Economy was developing since the 2000s with high enough growth rates in the original growing phases. During the Global Financial Crisis an economic cutback was recorded of around 14%. Thereafter, the economy commenced to recover with slow growth rates. At the end of 2014 and in the beginning of 2015, Country challenged a risk premium shock in the form of national currency depreciation against US dollar. This was typically a consequence of money transfers decline from the main partner country. One can observe the latter effect from Figure 2.1, where the yield spread is the difference between Armenian Euro-bonds' yield to maturity and US dollar spread curve with maturity of 7 years appropriately.

In addition, dollarization is another important indicator to look at in the context of evaluating exchange rate pass-through as it in some sense describes monetary policy credibility, which as it was stated in the theory is one of the key components of imperfections in ERPT. The dollarization level has been declining to 35.1% in monthly deposit dollarization rate and 36.9% rate of monthly credit dollarization in the beginning of 2008. After experiencing the Global Financial Crisis, deposit dollarization immediately increased reaching over 70%. Credit dollarization ratio was rising relatively slowly reaching over 50% in 2009 and continued rising further. Performing a slightly declining trend from 2012, however, both indicators started to decrease only after 2015 and reached around 50% recently.

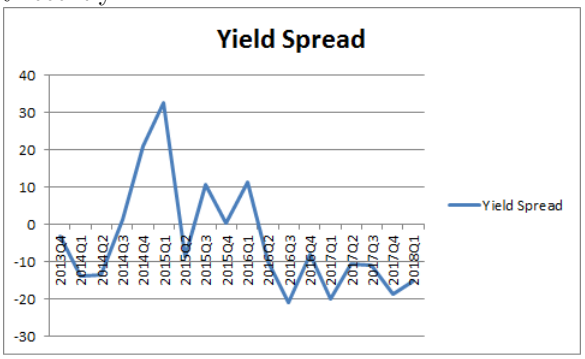


Figure 2.1 Evaluated Risk Premium

From the monetary policy point of view we are interested in exchange rate impact on core inflation as the latter is supposed to be less volatile part of the overall inflation. Besides, the share of imported goods is larger in the core inflation being slightly less than 53% compared to its share in consumer price index which compiles around 40%. Moreover, the dynamics of the import share change in core inflation is depicted in Figure 2.2. As it is obvious from the graph the share increased in 2015 compared to 2014, which was a consequence of the consumer basket content overview in 2015 when the share of imported goods has been risen and the share of core inflation has been declined. Further gradual decrease in following years is caused by the increase of core inflation share in headline inflation, meanwhile imported goods share remained relatively stable. Effective exchange rates are more important form monetary policy perspectives

too, as they are relative index measures of the currency against a basket of the partners' currencies.

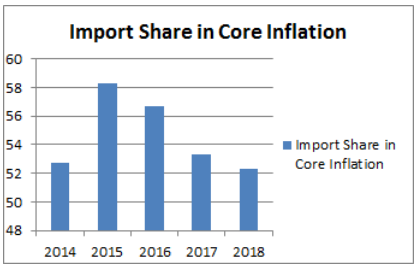


Figure 2.2 Import Share In Core Inflation [3]

Because real effective exchange rate is highly correlated with the nominal effective exchange rate, it is convenient to take the nominal rate series for estimation of the model. Additionally, nominal effective exchange rate performs a better correlation coefficients with both headline and core inflation compared to nominal exchange rate. We represent seasonally adjusted series of the change in nominal effective exchange rate and core inflation with the appropriate correlation coefficient of 0.3 and 0.32 between core inflation and the first lag of the nominal effective exchange rate.

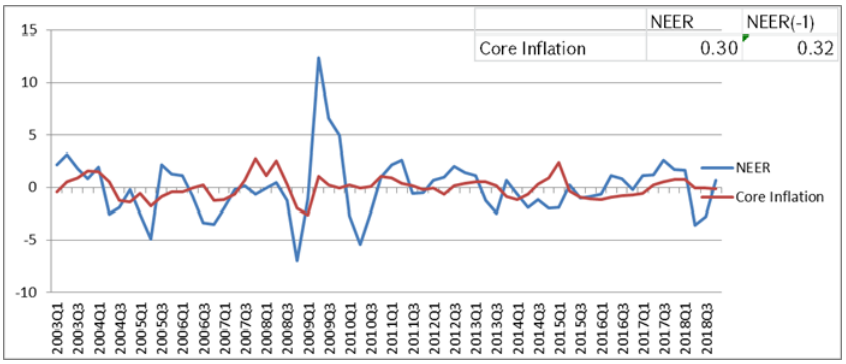


Figure 2.2 Nominal Effective Exchange Rate and Core Inflation

3.2 The Data

The data series are quarterly and have been seasonally adjusted to eliminate seasonality. In addition, all the series are submitted in their growth rates except Federal Reserve Effective Funds Rate and Interbank Repo Rate, which are in levels. The sample period starts from the first quarter of 2003 and ends at the forth quarter of 2018. The model includes seven variables, two of which are exogenous and exhibit the external sector. The remaining five variables correspond to the price dynamics, economic growth, monetary policy influence

[3] The index is evaluated by the specialists of the Central bank of Armenia

as well as the exchange rate. Further, increase in the graph of Nominal Effective Exchange Rate (NEER) index determines depreciation and the vice versa. The influence of global monetary policy change is demonstrated by Federal Reserve's Effective Funds Rate. We include this variable in the model in order to identify risk premium shock netting the effect of Fed Funds Rate in the exchange rate equation to obtain pure risk premium shock. An aggregated import price index in dollar terms illustrates the impact of foreign price dynamics to the domestic economy. This series capture the foreign price changes, it is in dollar terms in consideration to net the effect of foreign price changes from the exchange rate pass-through effect. We use GDP quarter on quarter growth series to take care of the demand side factors and the Core Inflation series to hold for the supply side factors. In addition GDP deflator is a proxy for intermediate consumption goods prices. Monetary policy is approximated by the Interbank REPO rate. And Nominal Effective Exchange Rate indicates exchange rate changes. We take the effective exchange rate as it occupies the exchange rates of the partner countries which is more relevant from the policy point of view which has been already mentioned. The input data of the model is depicted on the graph in Appendix 1 (Figure A1).

3.3 The Methodology

We use a semi-structural macroeconomic model to estimate the exchange rate pass-through for Armenia, which generally can be interpreted as the following equation below.

$$X_t = M X_{(t \quad n)} + Z_t$$

Where X_t is the vector of both endogenous and the exogenous variables, M is the VAR model specification coefficient matrix and Z_t is the vector of semi-structural shocks. n=0, 1, 2 by the lag length choice criteria represented by Table A1 in the Appendix 1. Thoroughly, the expanded structure can be interpreted as a matrix form representation which is depicted in Appendix 1, and the short functional forms of the system equations is exhibited beneath.

- $fedrate = F\{L(fedrate)\}$
- $imp\ price = F\{L(imp\ price)\}$

} **Exogenous Autoregressive**

- $y = F\{L(y), L(imp\ price), L(fedrate), L(pi), L(ydef), L(i), L(exch)\}$
- $pi = F\{L(y), L(imp\ price), L(fedrate), L(pi), L(ydef), L(i), L(exch)\}$
- $ydef = F\{L(y), L(imp\ price), L(fedrate), L(pi), L(ydef), L(i), L(exch)\}$
- $i = F\{L(y), L(pi), L(i)\}$ **The Rule**
- $exch = F\{L(y), L(imp\ price), L(fedrate), L(pi), L(ydef), L(i), L(exch)\}$

From the matrix representation, it becomes obvious that the first two variables are exogenous to the system depending only on their lag values. Next, the interest rate equation is set in a manner of Taylor rule. Further, we derive the appropriate VAR equation system for the latter with the use of some manipulations of matrix algebra. We estimate the parameters via the use of Bayesian estimation and depict the appropriate mode check plots as well as multivariate convergence in the Appendix 2 (Figure A2.1-A2.9). We perform the estimation for 2 data sets to evaluate the pass-through both before and after the risk premium shock which occurred at the end of 2014 and in the beginning of 2015. Furthermore, we identify 7 shocks for each of the variables and estimate the pass-through coefficients for some of the shocks. The resulting prior and posterior mean coefficients and the shocks of the long data estimation are depicted in Table A2.1, where one can detect that the values of the shocks are meaningful and consistent with economic theory. The order of the shocks coincides with the order of the equations mentioned above.

$$X_t = AX_t + BX_{(t\ \ 1)} + CX_{(t\ \ 2)} + Z_t$$

$$X_t = (I - A)\ \ ^1BX_{(t\ \ 1)} + (I - A)\ \ ^1CX_{(t\ \ 2)} + (I - A)\ \ ^1Z_t$$

$$X_t = B_1X_{(t\ \ 1)} + C_1X_{(t\ \ 2)} + DZ_t$$

Where $B_1 = (I - A)\ \ ^1B$, $C_1 = (I - A)\ \ ^1C$ and $D = (I - A)\ \ ^1$

3.4 Results

The estimation results are presented in the table below both for the short and long data. These coefficients are appropriate measures of long-run pass-through and are calculated with the use of the second formula illustrated under the Exchange Rate Pass-through Measures subsection. Hence the cumulative responses of the core inflation and exchange rate are depicted in Table 1 as well as their ratios as measures of the ERPT. According to the estimation the ERPT for the risk premium shock compiles to 0.17 for the long data and around 0.23 for the short data, which we attribute to be caused by the monetary policy credibility increase coming from the macroeconomic theory of incomplete pass-through and referring to monetary authority intervention to the risk premium shock occurred in 2014-2015.

		Fed Shock	Demand Shock	Supply Shock	MP shock	Risk Prem Shock
Long Data	Pi	0.31	0.08	0.70	-1.60	0.95
	Exch	2.10	-1.33	2.10	-2.61	5.60
	ERPT	0.15	-0.06	0.33	0.61	0.17
Short Data	Pi	1.07	0.47	0.87	-2.54	2.35
	Exch	4.35	-0.10	2.85	-5.34	10.29
	ERPT	0.25	-4.79	0.30	0.48	0.23

Table 1, Exchange Rate Pass-Through

In fact this hypothesis can be proved to be right if we take a look at the inflation expectations figured in Appendix 2 (Figure A2.17) before and after the risk premium shock. It is obvious from the graph that after the shock, inflation expectations declined significantly. Therefore, we attribute the long data pass-through decrease to monetary policy credibility increase. Indeed, the monetary policy shock share has risen for the long data estimation by 1% in variance decomposition of the exchange rate depicted in the Figure A 2.18 in the Appendix 2. The main changes in the shares of the shocks in exchange rate variance decomposition refer to demand shock share rise from 18% to 29%, risk premium shock share drop for 9 percentage points from 35% to 26% and to federal funds rate shock share cutback for 3 percentage points towards 2% for the long data estimation. The monetary policy role increase is easily detected from the pass-through coefficient of the monetary policy shock, which has increased for the long data as well. We also observe, that for the positive demand shock the pass-through coefficient is the smallest for the long data and for the short data as well. Obviously, the pass-through from demand shock with the long data estimation is the smallest in the range of all of the pass-through measures from different shocks, which coincides with the results of Forbes (2018). The magnitude of the absolute value of the latter can easily be explained with a negative demand shock which happened in the beginning of 2015 causing a big price decline. Generally, both demand shock and risk premium shock historically coincide with the events.

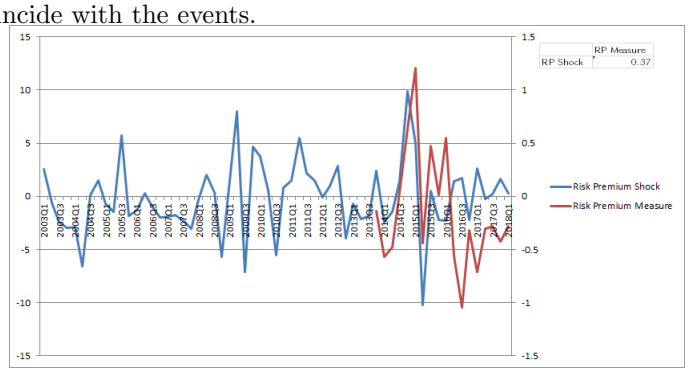


Figure 2.3, Risk Premium and Risk Premium Shock

This is visible from the demonstration of the historical risk premium shock given as the output of the model and risk premium measured by the difference of the Armenian yield curve and US dollar spread curve expressed in the Figure 2.3 above. These two series perform correlation of 0.37 starting from 2013, as the Armenian eurobonds were issued since September of 2013. Since 2003 and until 2008, we demonstrate a trending decrease in risk premium shock historical series, which was a historical fact, as the risk premium was declining under high development rates of the economy. In addition, the graph exhibits the Global Financial Crisis events appropriately.

Furthermore, historical demand shock also matches the historical events and possesses a correlation coefficient of 0.26 with the first lag of remittance series (Figure A2.19). The correlation with the first lag of the series is conditional on

the lag between receiving and spending.

To understand the functioning of the model and the transmission channels of the shocks, next we discuss the impulse-response functions based on the posterior mean of the estimated coefficients and standard deviations of the shocks. The Federal Funds rate seems to be the most persistent shock on the grounds that it returns to its steady level after 30 periods. The global monetary policy shock (see Appendix 2, Figure A2.14) has an influence similar to risk premium shock as it devaluates the exchange rate, because of the exchange rate depreciation foreign goods become more expensive, which rises the inflation. By the same mean demand for domestic products increases because they become cheaper. To alleviate inflation, the monetary authority increases the interest rates. This stimulates the exchange rate to be gradually evaluated and decreases the inflation. GDP deflator decreases as a result of monetary policy intervention as both intermediate and internal consumption of goods declines.

Import price shock (Figure A2.15 in Appendix 2) leads to an increase of overall prices in the economy, thus decreasing demand towards the goods and services, so GDP decreases.The fact that the prices of intermediate goods increases promotes GDP to decrease as well. The monetary authority pushes the interest rates downward as the demand went too far down from its steady state. The exchange rate depreciates initially in accordance with the monetary policy loosening the interest rates. And afterwards when the interest rates start to adjust up, the exchange rate starts to appreciate.

Demand shock is depicted via the rise of GDP in Appendix 2 by Figure A2.16. As soon as GDP accelerates, it generates an increase in prices according to the law of demand, monetary policy interferes to bring inflation back, as a result of the capital inflow rise exchange rate appreciates. The decrease of GDP deflator refers to the intermediate goods price cut down on the grounds of exchange rate appreciation.

Supply shock is represented by a negative productivity shock accompanied by the rise of inflation and particularly by core inflation in this model exhibited by Figure A2.17 in Appendix 2. Generally, as productivity diminishes in the economy, this leads to an increase in marginal costs, thus increasing prices. As prices increase people start to consume less and demand declines exhibiting a cutback in GDP. To restraint the inflation the central bank increases its interest rate. Exchange rate depreciates because of export drop despite the fact that the monetary policy has risen the interest rates. In addition, GDP deflator decreases as a response to monetary policy tightening.

When intermediate consumption goods become more expensive demonstrated by an increase in GDP deflator (see Figure A2.18 in Appendix 2), it compasses to overall prices in the economy. So this shock is similar to negative productivity shock, demand decreases as a result of price increase, monetary policy constraints inflation with an augmentation in interest rates again. The exchange rate starts to appreciate after initial depreciation referred to export decline.

In the consequence of a monetary policy shock indicated in the Figure A2.19 in Appendix 2, demand towards commodities and services declines, as the alternative costs to consumption increase in a manner that a less unit of consumption

now can generate more in the future if it is invested. As a result producers start to decrease the prices on goods and services. On the other hand exchange rate appreciates because of more capital inflows to the country.

Risk premium shock (Figure A2.20 in Appendix 2) is identified as the semi-structural shock of the exchange rate equation, so when there is a positive risk premium shock, exchange rate depreciates. The latter causes an initial increase in GDP via an export growth, as domestic products become cheaper for the partners and they start to consume more of the goods. This leads to an inflation. On the other hand while the economy possesses foreign currency debt a balance-sheet effect decreases demand. Furthermore GDP deflator decline expresses exportable goods price reduction. To bring the inflation back, monetary authority increases the policy rate.

The dynamics of the pass-through coefficients from risk premium shock, federal funds shock are depicted in the graphs below. These are also the representations of time-varying pass-through dynamics. We discuss the dynamics of the ERPT of those shocks because the context of this paper is devoted to the discovery of the risk premium shock pass-through and its dynamics. Moreover, the delineation of the ERPT in the case of global monetary policy shock is conditional on its similarity to risk premium shock in its transmission channel frame of reference. Some interesting inferences are followed from these figures. In the state of more credible monetary policy performance (i.e. with the long data estimation) we notice a smaller initial pass-through elasticity in both of the shocks. Also, as it has been discussed above the long run pass-through measures are also less in the case of long data. We also detect a more rapid decline in the dynamics of pass-through in the case of long data. The latter is consistent with the framework of the macroeconomic view about the exchange rate pass-through. Another important fact is that in both cases the initial pass-through fulfills a decrease and the long run coefficient is lower as an outcome. From our point of view that is a consequence of price stickiness, because the prices adjust slower as long as a part of price setters do change the prices and some part of them do not. And in addition, exchange rate movements are not limited as much as the prices' ability to go up or down. This is obvious from the impulse-response analysis of the shocks. It can even be observed in responses of the core inflation during the federal funds and demand shocks, of course the shocks generated from the equations of any price index are an exception to this. However, the low stickiness during the risk premium shock can be explained by the inflationary environment change related to inflation expectations based on the exchange rate volatility. In addition, an observation of the prices of product and service groups included in core inflation shows that a major part of them has increased during the risk premium shock recorded at the end of 2014 (Check Figure A2.21 in Appendix). Both the three month and four month average price inflations of those products and services starting from November of 2014 are significantly higher than the historical average and the share of the products and services with higher average rates for the 3-4 month period compiles to 67.7% in 12 month period core inflation. So the final inference is that the fact that we do not notice price stickiness in the original phase of the risk premium shock might

not be supposed as a destitute of the estimation but actuality of the functioning of the economy.

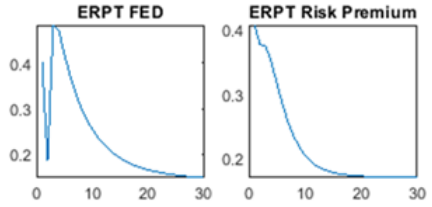


Figure 2.4, ERPT For Long Data

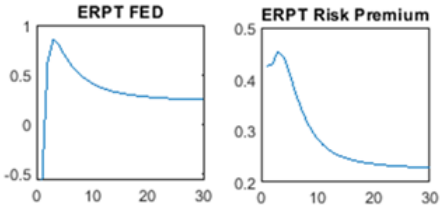


Figure 2.5, ERPT For Short Data

What concerns to monetary policy shock, a little price stickiness is observed in the initial period of the shock, anyway this result might be improved by a usage of a fully structural model.

4 Conclusions

To sum up, we developed a semi-structural macroeconomic model to estimate exchange rate pass-through from risk premium shock. The long run estimate for the latter compiled to 0.17, and taking into account the fact that imported goods share in core inflation is around 0.52, the estimated pass-through to import prices is around 0.32 in the long run. In addition, we calculated the pass-through coefficients for the rest of the shocks to find out which of the shocks causes the biggest pass-through coefficients both in short and long run periods. The results demonstrate that the least pass-through coefficient is recorded during the demand shock which is consistent with the existing literature. The output also shows that the federal reserve shock is a persistent one, and as a look-alike to the risk premium shock in the sense of the effects on the economy, it in addition, brings pass-through measure closer to the one from the risk premium shock. One of the differences between the global monetary policy shock and risk premium shock is the diminutive price-stickiness during the risk premium shock. Furthermore, the results from the short data estimation show that for the recent years monetary policy credibility played an important role for the long run pass-through coefficients compared to the long data. Moreover, as a model robustness some of the resulting historical shocks perform very similar resemblance of their historical measures.

5 References

1. Lian An. 2006. "Exchange Rate Pass-Through:Evidence Based on Vector Autoregression with Sign Restrictions". Department of Economics University Of Kentucky. October 2006

2. Raphael Auer, Thomas Chaney, 2009."Exchange Rate Pass-Through in a Competitive Model of Pricing-to-Market". Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute. January 2009. Working Paper No.23

3. Jose Manuel Campa, Linda S. Goldberg. 2002. "Exchange Rate Pass-Through Into Import Prices: A Macro Or Micro Phenomenon?". National Bureau Of Economic Research.May 2002. Working Paper 8934

4. Ehsan U. Choudhri, Dalia S. Hakura. 2001. "EXchange RAte Pass-Through to Domestic Prices: Does the Inflationary Environment Matter?". December 2001. IMF Working Paper WP/01/194

5. Michael B. Devereux, Charles Engel. 2002."Exchange Rate Pass-Through, Exchange Rate Volatility, And Exchange Rate Disconnect". National Bureau Of Economic Research. April 2002. Working Paper 8858

6. Devereux, M. and J. Yetman. 2002. âPrice Setting and Exchange Rate Pass-Through: Theory and Evidence.â In Price Adjustment and Monetary Policy. Proceedings of a conference held at the Bank of Canada, November 2002. Ottawa: Bank of Canada.

7. Kristin Forbes, Ida Hjortsoe, Tsvetliana Nenova. 2018. "The Shocks Matter: Improving Our Estimation Of Exchange Rate Pass-Through". National Bureau Of Economic Research.June 2018. Working Paper 24773

8. Pinelopi K. Goldberg and Rebecca Hellerstein. 2008. "A Structural Approach to Explaining Incomplete Exchange-rate Pass-through and Pricing-To-Market". Federal Reserve Bank of New York

9. Pinelopi K. Goldberg, Michael M. Knetter. 1996 , "Goods Prices And Exchange Rates: What Have We Learned?". National Bureau Of Economic Research. December 1996. Working Paper 5862

10. Martina Jasova, Richhild Moessner and Elod Takats. 2016. "Exchange Rate pass-through: What has changed since the crisis".September 2016. BIS Working Paper No 583

11. Paul Krugman. 1986. "Pricing To Market When The Exchange Rate Changes".National Bureau Of Economic Research. May 1986. Working Paper No. 1926

12. Daniel Leigh, Marco Rossi. 2002. "Exchange Rate Pass-Through in Turkey". International Monetary Fund. November 2002. WP/02/204

13. Antonia Lopez-Villavicencio and Valerie Mignon. "On the Seemingly Incompleteness of Exchange Rate Pass-through to Import Prices: Do Globalization and/or Regional Trade Matter?". CEPII Working Paper No.2017-08-June

14. Richard C. Martson. 1989. "Pricing to Market In Japanese Manufacturing". National Bureau Of Economic Research. March 1989. Working Paper No. 2905

15. Laurence Savioe-Chabot and Mikael Khan. 2015. "Exchange Rate Pass-Through to Consumer Prices:Theory and Recent Evidence" Bank of Canada. October 2015. Discussion Paper 2015-9

16. Jonas Stulz. 2007."Exchange rate pass-through in Switzerland: Evidence from vector autoregressions", Swiss National Bank No.4 2007

17. Yelena Takhtamanova. 2008. "Understanding Changes in Exchange Rate Pass-Through". Federal Reserve Bank of San Francisco. February 2008. Working Paper 2008-13

18. John B. Taylor. 2000. "Low inflation, pass-through, and the pricing power of firms". European Economic Review 44(2000) 1389-1408

19. BALÃZS VONNÃK. 2010."Risk premium shocks, monetary policy and exchange rate pass-through in the Czech Republic, Hungary and Poland". Magyar Nemzeti Bank.January 2010. MNB Working Papers 2010/1

6 Appendices

6.1 Appendix 1

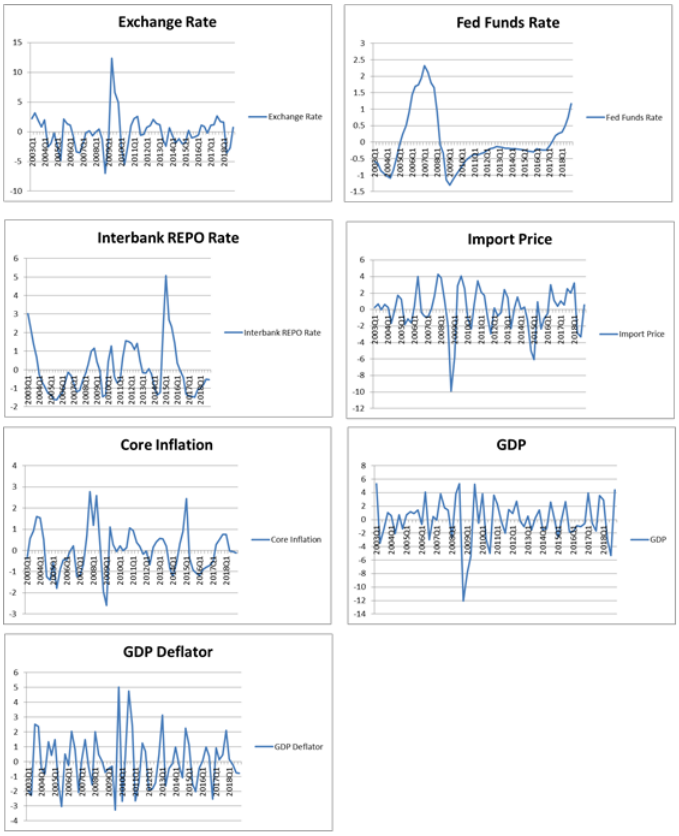


Figure A1, Input Data

VAR Lag Order Selection Criteria
Endogenous variables: Y YDEF PI I EXCH
Exogenous variables: FED IMPORT_PRICE
Date: 03/04/19 Time: 11:56
Sample: 2003Q1 2018Q1
Included observations: 56

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-524.2711	NA	133.2036	19.08111	19.44278	19.22133
1	-460.0070	112.4622	32.98353	17.67882	18.94467*	18.16959*
2	-427.6098	50.90993*	26.02305*	17.41463*	19.58465	18.25595
3	-405.5171	30.77191	30.81058	17.51847	20.59266	18.71033
4	-384.7045	25.27243	40.52033	17.66802	21.64639	19.21042
5	-361.5588	23.97237	53.57875	17.73424	22.61679	19.62719

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table A1, Lag Selection Criteria

Matrix Form Representation of the Model

$$
\begin{bmatrix} Fed_t \\ Imppr ice_t \\ gdp_t \\ pi_t \\ ydef_t \\ i_t \\ exch_t \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 8 & 4 & 0 & 12 & 16 & 20 & 24 \\ 8 & 4 & 12 & 0 & 16 & 20 & 24 \\ 8 & 4 & 12 & 16 & 0 & 20 & 24 \\ 0 & 0 & 12 & 16 & 0 & 0 & 0 \\ 8 & 4 & 12 & 16 & 20 & 24 & 0 \end{bmatrix} \text{x} \begin{bmatrix} Fed_t \\ Imp_t \\ gdp_t \\ pi_t \\ ydef_t \\ i_t \\ exch_t \end{bmatrix}
$$

$$
+ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 5 & 1 & 13 & 17 & 21 & 25 \\ 9 & 5 & 13 & 1 & 17 & 21 & 25 \\ 9 & 5 & 13 & 17 & 1 & 21 & 25 \\ 0 & 0 & 13 & 17 & 0 & 1 & 0 \\ 9 & 5 & 13 & 17 & 21 & 25 & 1 \end{bmatrix} \text{x} \begin{bmatrix} Fed_{t\ 1} \\ Imp_{t\ 1} \\ gdp_{t\ 1} \\ pi_{t\ 1} \\ ydef_{t\ 1} \\ i_{t\ 1} \\ exch_{t\ 1} \end{bmatrix}
$$

$$
+ \begin{bmatrix} 2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & rho2 \end{bmatrix} \text{x} \begin{bmatrix} Fed_{t\ 2} \\ Imp_{t\ 2} \\ gdp_{t\ 2} \\ pi_{t\ 2} \\ ydef_{t\ 2} \\ i_{t\ 2} \\ exch_{t\ 2} \end{bmatrix} + \begin{bmatrix} zfed_t \\ zImp_t \\ zgdp_t \\ zpi_t \\ zydef_t \\ zi_t \\ zexch_t \end{bmatrix}
$$

6.2 Appendix 2

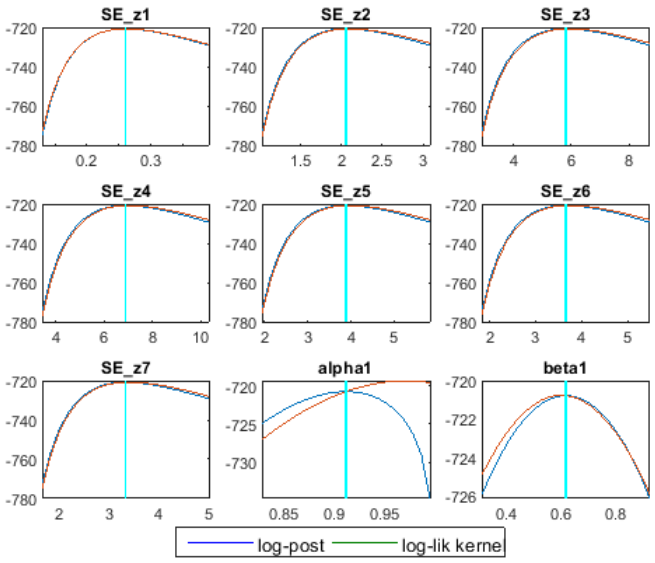


Figure A2.1, Mode Check Plot 1

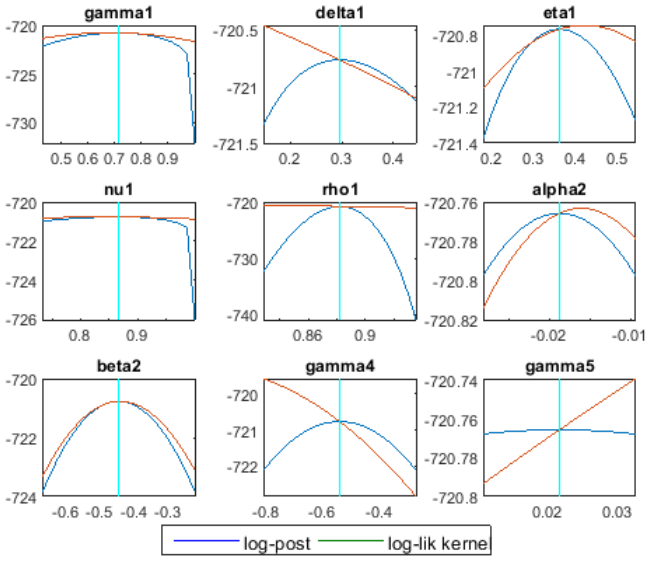


Figure A2.2, Mode Check Plot 2

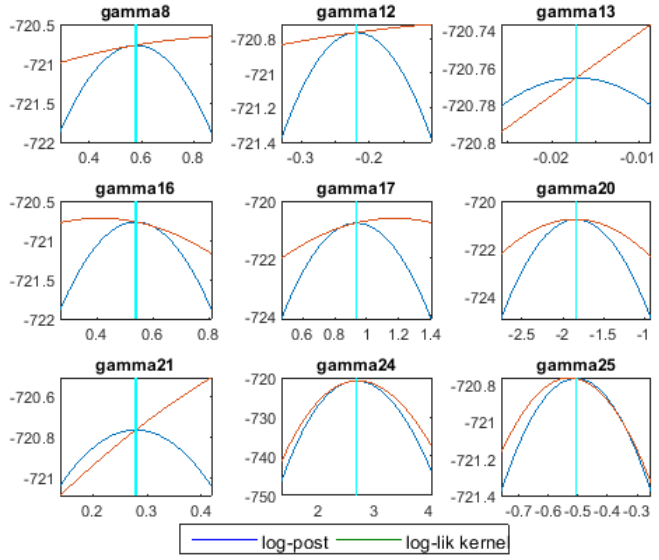


Figure A2.3, Mode Check Plot 3

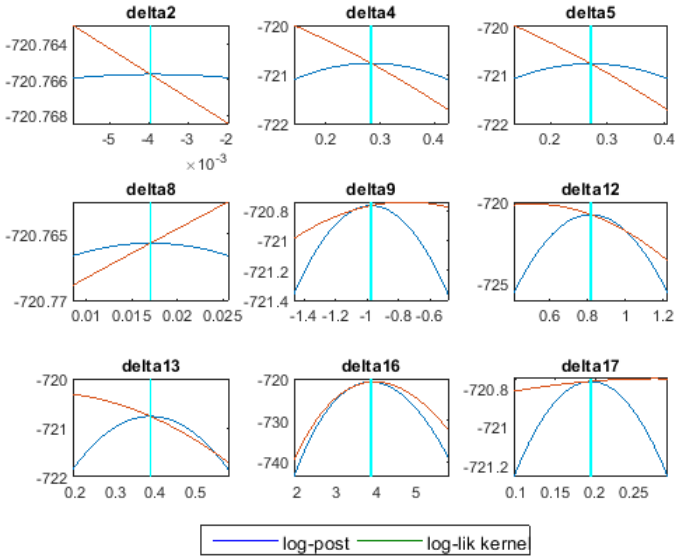


Figure A2.4, Mode Check Plot 4

beginfigure1

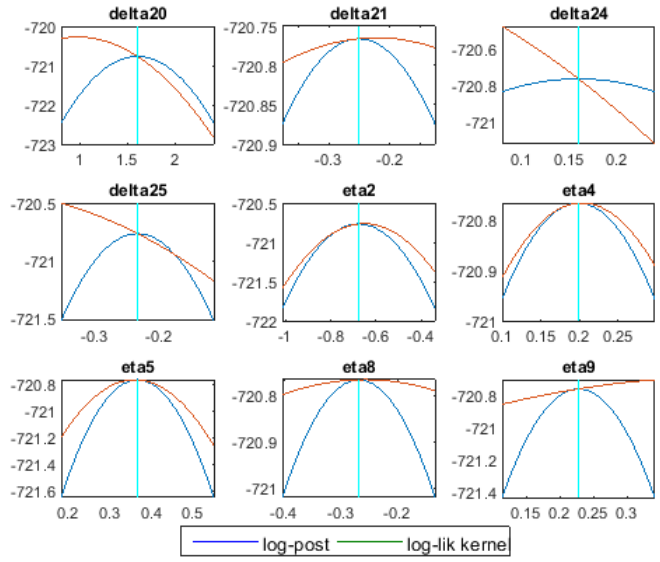


Figure A2.5, Mode Check Plot 5

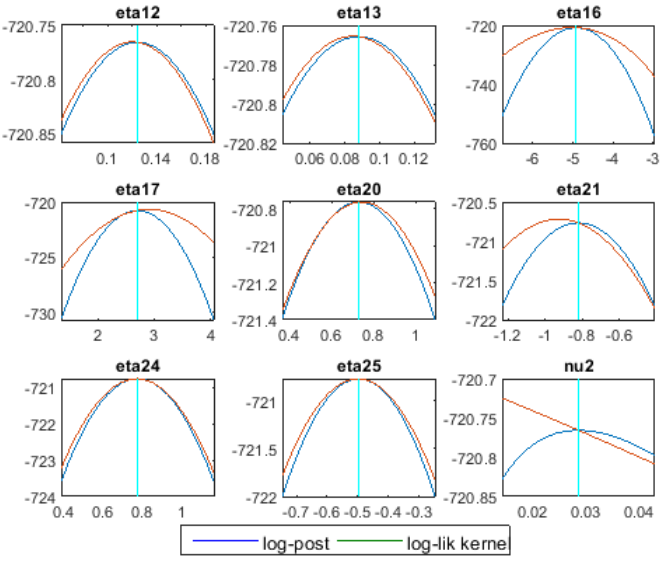


Figure A2.6, Mode Check Plot 6

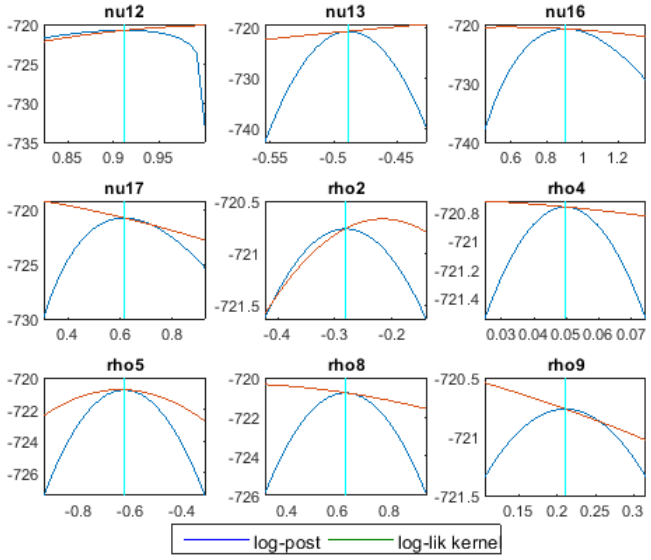


Figure A2.7, Mode Check Plot 7

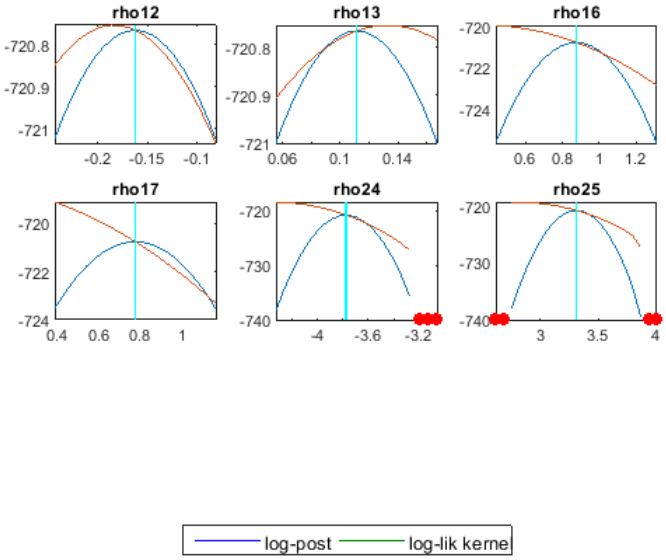


Figure A2.8 Mode Check Plot 8

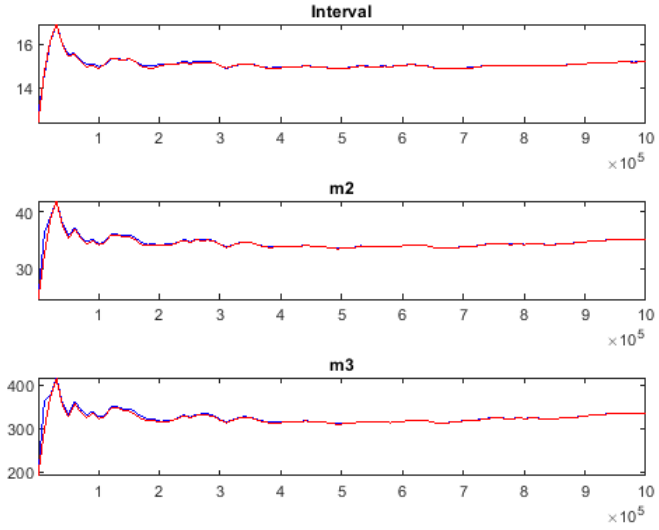


Figure A2.9, Multivariate Convergence

parameters

	prior mean	post. mean	90% HPD interval		prior	pstdev
α_1	0.750	0.8979	0.8409	0.9566	beta	0.0800
β_1	0.647	0.6118	0.4406	0.7853	beta	0.2000
γ_1	0.662	0.6760	0.4400	0.9033	beta	0.1800
δ_1	0.394	0.3423	0.1033	0.5735	beta	0.1560
η_1	0.379	0.3902	0.1154	0.6510	beta	0.1740
ν_1	0.715	0.7482	0.5207	0.9965	beta	0.1890
ρ_1	0.882	0.8818	0.8657	0.8985	beta	0.0100
α_2	-0.094	-0.0090	-0.0912	0.0730	norm	0.2000
β_2	-0.462	-0.4429	-0.5999	-0.2814	norm	0.2000
γ_4	-0.297	-0.5327	-0.8136	-0.2492	norm	0.2000
γ_5	-0.078	0.0255	-0.2642	0.3164	norm	0.2000
γ_8	0.556	0.5819	0.2607	0.8964	norm	0.2000
γ_{12}	-0.224	-0.2228	-0.3834	-0.0625	norm	0.1000
γ_{13}	-0.025	-0.0187	-0.1007	0.0633	norm	0.0500
γ_{16}	0.569	0.5329	0.2217	0.8370	norm	0.2000
γ_{17}	0.882	0.9038	0.6388	1.2395	norm	0.2000
γ_{20}	-1.829	-1.8421	-2.3978	-1.2810	norm	0.4000
γ_{21}	0.195	0.2771	-0.0408	0.5954	norm	0.2000
γ_{24}	2.611	2.7698	2.3029	3.2138	norm	0.4000
γ_{25}	-0.426	-0.5203	-0.9570	-0.0781	norm	0.5000
δ_2	0.010	-0.0033	-0.1692	0.1592	norm	0.1000
δ_4	0.527	0.3031	0.0074	0.6053	norm	0.2000
δ_5	0.529	0.2883	-0.0165	0.5907	norm	0.2000
δ_8	0.002	0.0122	-0.3074	0.3431	norm	0.2000
δ_9	-1.031	-1.0050	-1.7605	-0.2564	norm	0.5000
δ_{12}	0.910	0.8312	0.6041	1.0615	norm	0.1500
δ_{13}	0.468	0.3983	0.1748	0.6188	norm	0.1500
δ_{16}	3.633	4.1112	3.2494	4.9812	norm	0.6000
δ_{17}	0.191	0.1945	0.0366	0.3569	norm	0.1000
δ_{20}	2.171	1.6391	0.8317	2.4339	norm	0.6000
δ_{21}	-0.258	-0.2552	-0.7232	0.2021	norm	0.3000
δ_{24}	0.520	0.1912	-0.1833	0.5735	norm	0.3000
δ_{25}	-0.205	-0.2306	-0.3887	-0.0724	norm	0.1000
η_2	-0.726	-0.6808	-1.1010	-0.2674	norm	0.4000
η_4	0.188	0.1630	-0.1983	0.5297	norm	0.3000
η_5	0.372	0.3599	0.0758	0.6338	norm	0.2000
η_8	-0.270	-0.2825	-0.6011	0.0321	norm	0.2000
η_9	0.221	0.2256	0.0735	0.3842	norm	0.1000
η_{12}	0.255	0.2116	-0.1327	0.5482	norm	0.8800
η_{13}	0.169	0.1190	-0.2022	0.4464	norm	0.7900
η_{16}	-4.862	-5.0344	-5.4867	-4.5815	norm	0.3000
η_{17}	2.558	2.6896	2.1213	3.2439	norm	0.4000
η_{20}	0.637	0.5568	-0.2672	1.3756	norm	0.8900
η_{21}	-0.594	-0.7224	-1.3659	-0.0648	norm	0.5000
η_{24}	0.815	0.8010	0.4234	1.1810	norm	0.5000
η_{25}	-0.481	-0.5138	-0.8571	-0.1698	norm	0.4000
ν_2	0.129	0.1022	0.0002	0.2111	beta	0.1000
ν_{12}	0.762	0.8797	0.7857	0.9811	beta	0.1200
ν_{13}	-0.491	-0.4877	-0.5041	-0.4715	norm	0.0100
ν_{16}	0.932	0.9248	0.7622	1.0909	gamma	0.1000
ν_{17}	0.683	0.6318	0.4821	0.7762	gamma	0.1000
ρ_2	-0.345	-0.2891	-0.4679	-0.1050	norm	0.1500
ρ_4	0.051	0.0489	0.0163	0.0813	norm	0.0200
ρ_5	-0.619	-0.6200	-0.7653	-0.4743	norm	0.1000
ρ_8	0.647	0.6292	0.4697	0.7921	norm	0.1000
ρ_9	0.234	0.2121	0.0517	0.3721	norm	0.1000
ρ_{12}	-0.117	-0.1742	-0.3718	0.0202	norm	0.2000
ρ_{13}	0.100	0.1137	-0.0225	0.2493	norm	0.1000
ρ_{16}	0.950	0.8799	0.6452	1.1098	norm	0.1500
ρ_{17}	0.950	0.7737	0.4934	1.0488	norm	0.1800
ρ_{24}	-0.694	-0.7818	-0.9389	-0.6275	norm	0.1000
ρ_{25}	0.370	0.3059	0.1459	0.4612	norm	0.1000

standard deviation of shocks

	prior mean	post. mean	90% HPD interval		prior	pstdev
s1	0.500	0.2693	0.2286	0.3093	invg	3.0000
s2	1.500	2.1211	1.8089	2.4296	invg	5.0000
s3	1.500	6.1767	4.9589	7.3508	invg	5.0000
s4	1.100	7.5430	5.6985	9.3715	invg	4.2000
s5	1.300	4.3564	3.5441	5.1426	invg	4.5000
s6	0.800	3.6817	3.0753	4.2775	invg	3.0000
s7	1.200	3.4562	2.9218	3.9746	invg	4.5000

Table A2.1, Prior and Posterior Estimation Results

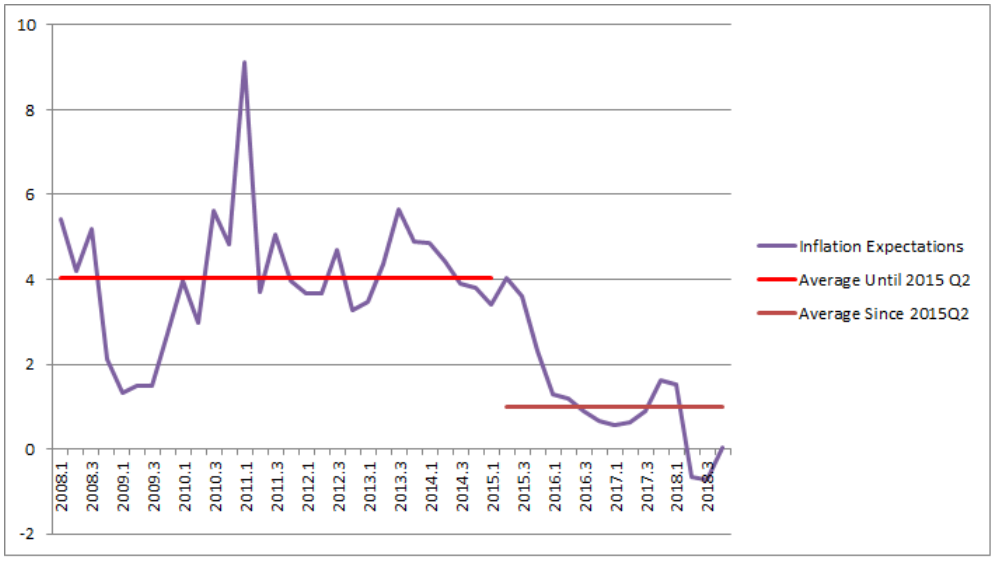


Figure A2.10, Inflation Expectations

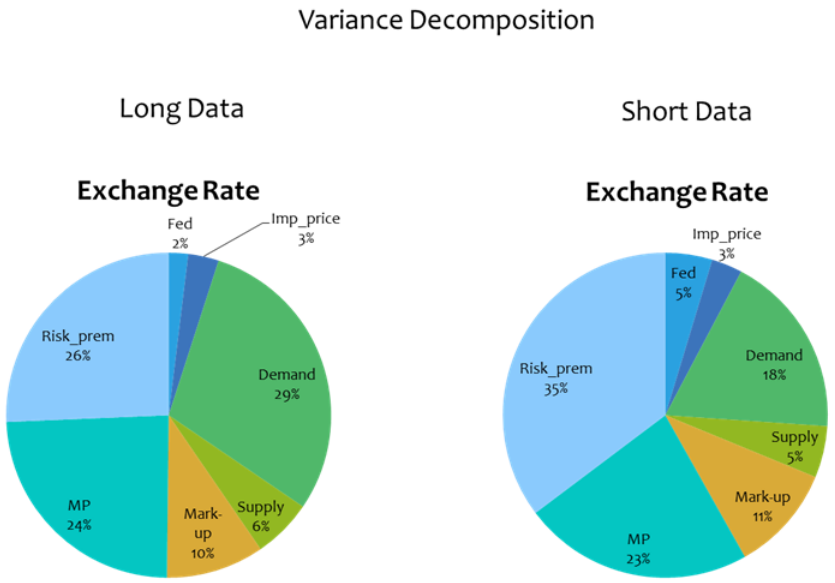


Figure A2.11, Variance Decomposition

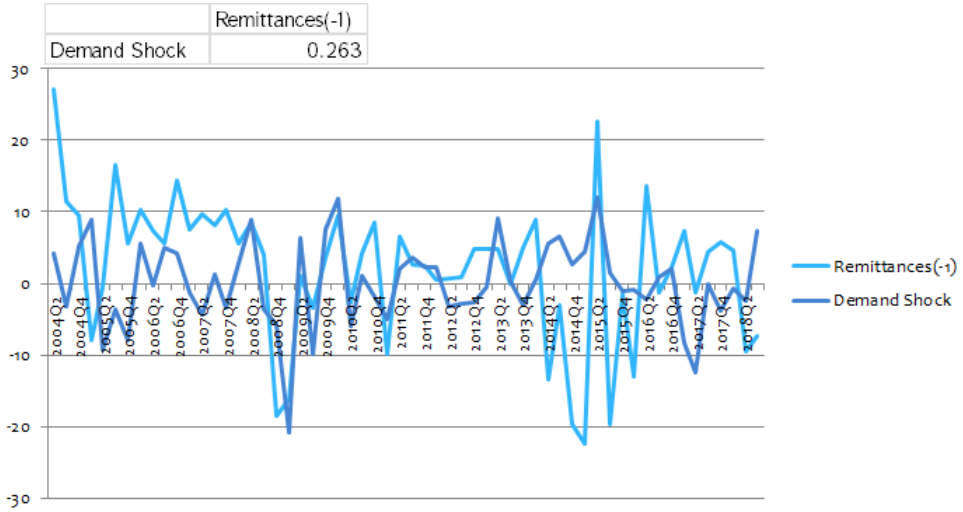


Figure A2.12, Demand Shock and Remittances

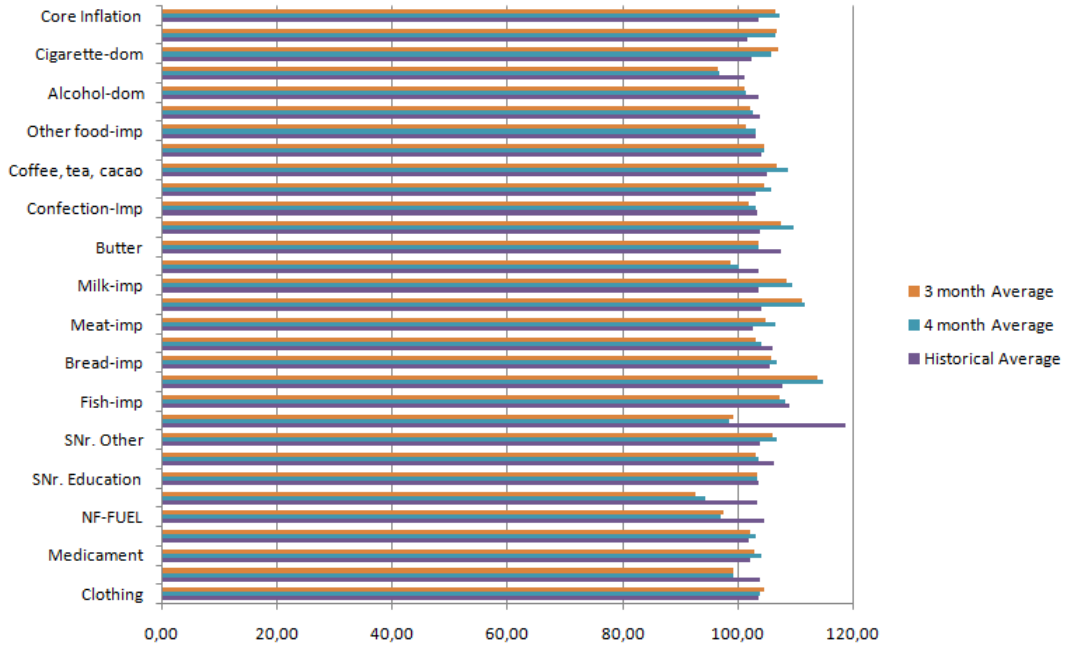


Figure A2.13, Prices' Response to a Risk Premium Shock

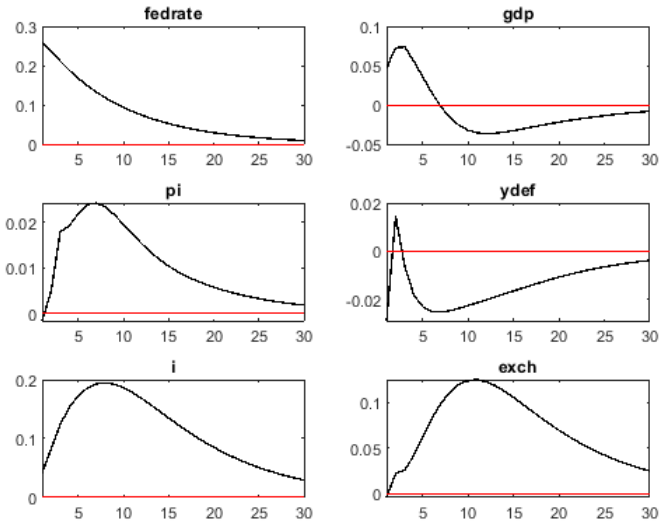


Figure A2.14, Federal Fund's Shock

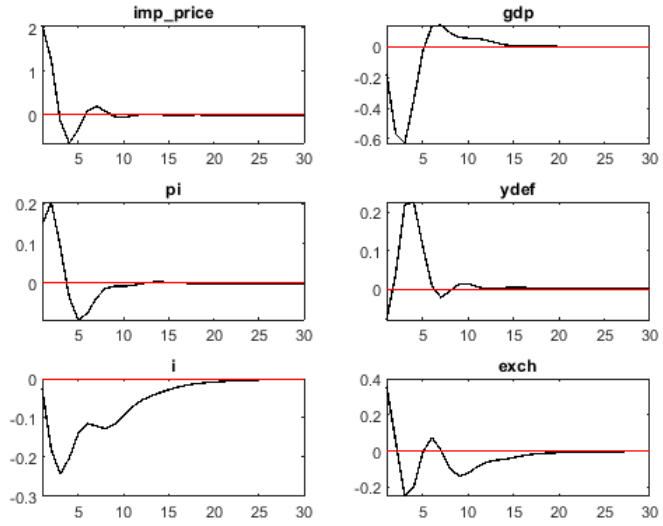


Figure A2.15, Import Price Shock

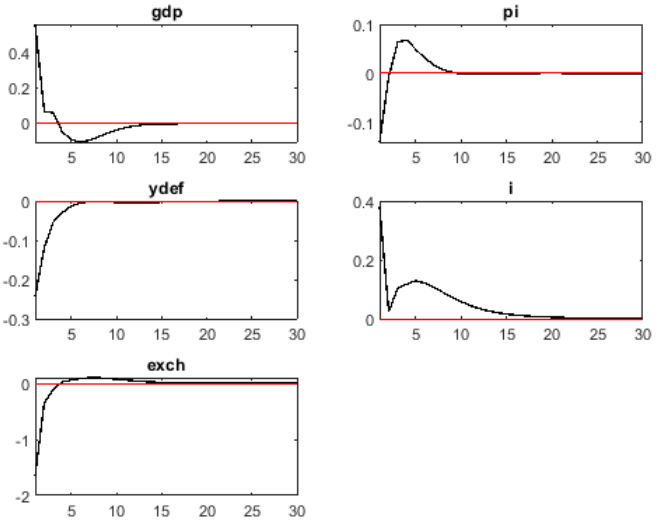


Figure A2.16, Demand Shock

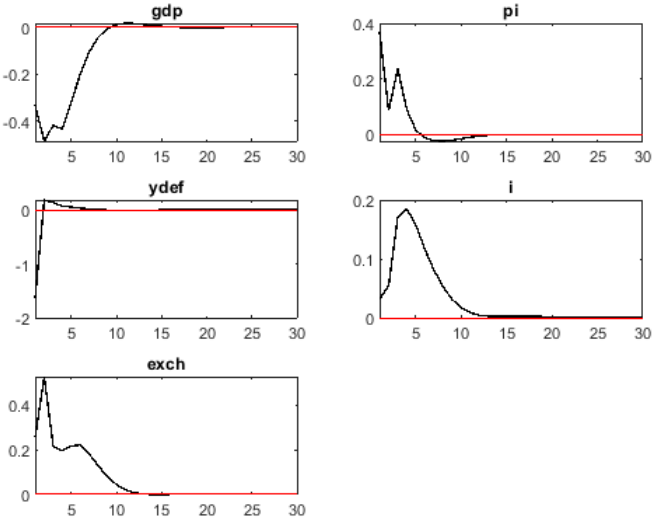


Figure A2.17, Supply Shock

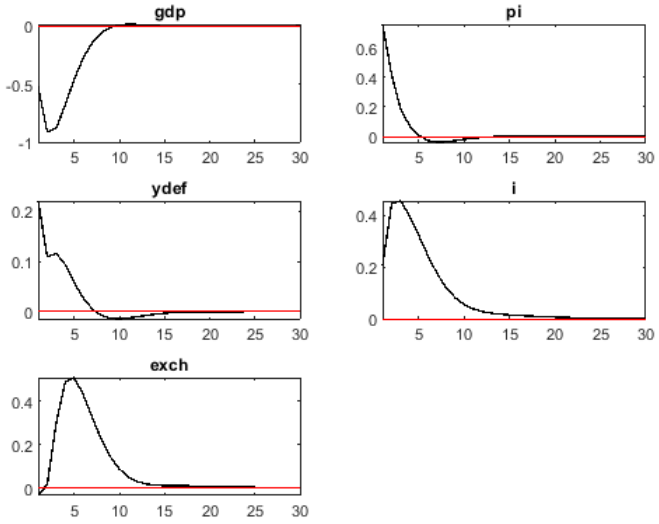


Figure A2.18, Intermediate Consumption Shock

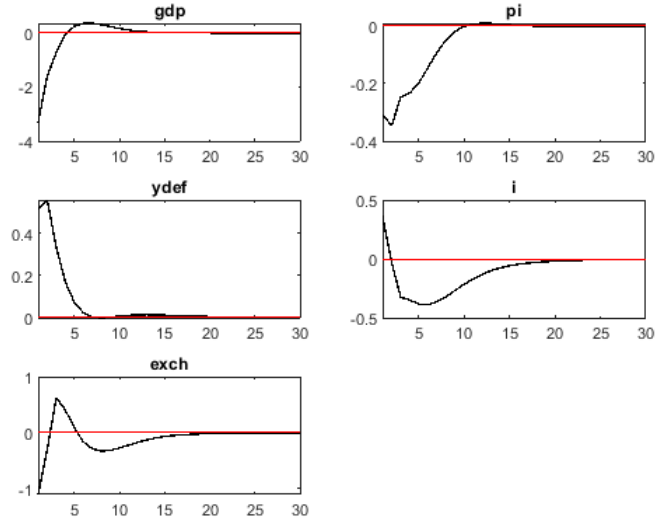


Figure A2.19, Monetary Policy Shock

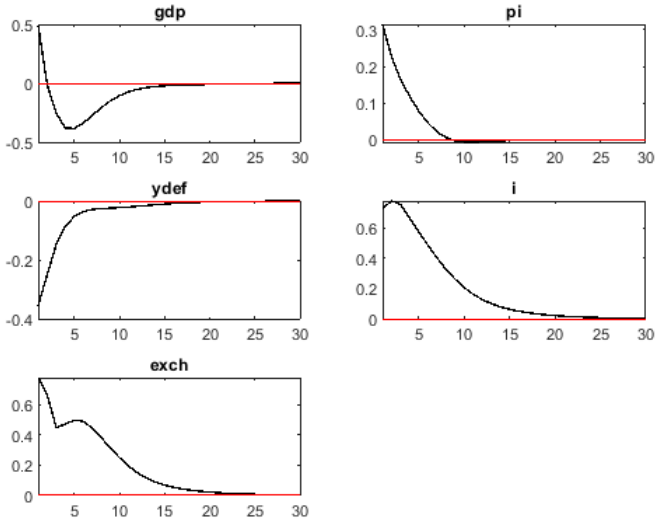


Figure A2.20, Risk Premium Shock