Central Bank Credibility and Black Market Exchange Rate Premia: A Panel Time Series Analysis

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Abstract

The major goal of this study was analyze the effect of "credibility" shocks to the dynamics of inflation persistence in 20 countries using quarterly data for the period 1980-1998. To address this topic, we used recently developed heterogeneous panel time series methods and found that central bank credibility, as inferred from the black market premium, impacted the degree of inflation persistence associated with central bank interventions and that the magnitude of this effect was correlated with the degree of central bank autonomy.

Keywords: Central bank credibility, black market exchange rate, heterogeneous dynamic panel, panel VAR

JEL Classification: C13, C23, E58

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1. Introduction

There is a common recognition that a black market for exchange rate emerges out of government restrictions on holding foreign assets. These restrictions lead to a rise in unofficial trade at prices that more accurately reflect actual supply and demand conditions (Agenor, 1992). Inefficient intervention of Central Bank (CB) to market can even distort the behavior of market agents leading to an increase in the spread between black market and official rate, called black market premium. Therefore, a significant spread between black market and official rate may be a signal of macroeconomic misalignment, and consequently central banks will often intervene in the official market to eliminate the spread (Miguel and O'Connel, 1995). This implies that the dynamics of black market premium can be considered to reflect the general public confidence to the performance of economy, as well as CB monetary policy.

In that sense, the problem of beliefs towards CB monetary policy lies on asymmetric information that arises between the central bank (CB) and the public. When CB conducts its monetary policy public has little information on further actions of CB and policymakers commitment to it. One way to show its commitment is to undertake a strategy that could be clearly observed by the public like central bank independence or fixed exchange rate, which are argued to be more costly to renege from rather than to revoke from a simple commitment (Keefer and Stasave, 2002). A large body of theoretical and empirical studies emphasizes the importance of this asymmetry in effectiveness of disinflation programs (Kydland and Prescot,1977; Backus D. and Driffil, 1985; Agenor and Taylor, 1993; Ball, 1990). The main argument is that when the public believes that the disinflation will be in fact carried out, the costs of disinflation program will be smaller (McCallum, 1997). In the literature, "public believes" toward monetary policy refers to "credibility" of monetary policy.

Beginning from the 1980s, due to increasing role of oil prices on general economic environment, in most countries, the reduction of inflation was costly in terms of recession and increases in unemployment rates (David et al., 1990). While disinflationary policies were costly, the central banks started to lose credibility, therefore, when a disinflationary program lacks credibility, agents anticipate resumption in inflation (Agenor and Taylor, 1993). The argument was developed by Kydland and Prescot (1977) who introduced the concept of credibility of

implemented policies. They claimed that the public assigns a probability to policymakers' commitments to reach some policy targets, and therefore, low credibility rather than irrational decision-making might explain the highly persistent inflation in an economy.

Hence, the effectiveness of stabilization program depends on the role of credibility factors. When policies implemented lack credibility, private agents would eventually recognize that the government efforts to maintain a consistent set of policies over time would not be successful and the announced disinflation program would not be sustainable in the long-run. On the other hand, when the public is confident in the ability of policymakers to carry out a newly announced stabilization program, the inflationary process will be reduced by changing inflationary expectations. Since inflationary expectations have a significant effect on current wage and price decisions, a reduction in the actual inflation may result. (David et al., 1990).

These arguments imply that lack of credibility of monetary policy is one of the major challenges for Central Banks to keep inflation low and stable in order to maintain financial stability and promote high growth. Moreover, there is a general recognition in academic and empirical literature that the primary goal for monetary policy is price stability. Other objectives such as promoting growth and employment are seen as secondary. The rationale is that the best way that a central bank can promote growth and employment is by keeping inflation low and stable. In that context, credibility becomes a central issue in disinflation programs as well as for monetary policy.

Therefore, the major goal of this study is analyze the effect of "credibility" shocks to the dynamics of inflation in 20 countries using quarterly data for the period 1980-1998 by employing two different econometric techniques. In the first part of the analysis we apply Kalman filter techniques following Agenor and Taylor (1993) methodology. The key idea of their analysis was to observe credibility of disinflation program in inflation persistence dynamics.

In the second part of my analysis we apply heterogeneous vector autoregressive (VAR) panel technique following Pedroni (2008) and Pedroni (2013). The main motivation to employ VAR analysis is to build analysis based on multivariate context, while Kalman Filter methodology of Agenor and Taylor (1993) restricted on univariate form. Another reason to apply VAR approach is to analyze inflation in terms of different type of shocks, particularly to observe whether credibility shocks differ from inflation shocks.

The remaining part of the thesis consists of the following sections. In *Literature Review* section we review some existing literature on credibility role in monetary policy and existing mythologies

to measure it. In *Methodology* section we discuss about measurement problem of credibility, and the econometric methodology to be applied, as well as data description. In *Empirical Results* section will discuss about econometric estimation results of the theory. In *Conclusion* section we summarized the main results. In addition, *Appendix* contains some results of econometric test statistics and graphs.

2. LITERATURE REVIEW

It is generally recognized that the source of credibility lies in the time inconsistency of optimal policies (Kydland and Prsecott 1977). Time-inconsistency in monetary policy arises from a policymaker's futile attempt to stimulate output above the natural level, resulting in an inflationary bias under discretionary monetary policy. The standard explanation of this inflationary bias is based on a two-way interaction between policymakers and a rational public within the context of expectations-augmented Phillips curve in a game-theoretic approach. Under discretion, policymakers try to create inflation surprises in order to push employment above its natural level towards the higher desired level. However, individuals understand the temptation of policymakers and correctly forecast inflation, neutralizing any effect of inflation on employment. As a consequence, employment remains at its natural level but inflation bias arises. This is a dynamic inconsistency of optimal monetary policy under discretion (Kydland and Prsecott 1977, Barro and Gordon 1983).

A large body of literature has been developed to examine alternative solutions to the inflationary bias of time-inconsistent monetary policy under discretion (Rogoff (1985), Canzonery(1985), Flood & Isard (1989), Lohmann (1992), Walsh (1995), McCallum (1995,1997), Svensson (1997)). Rogoff (1985) analyzes the preferences of the central bank to solve the time-inconsistency problem and suggests that the government should appoint a "conservative" central banker who places greater relative weight on the inflation objective than does society (the government) as a whole. In other words, the government should delegate responsibility for monetary policy to an independent central bank. An independent central bank is able to set policy to minimize its own assessment of social costs. Thus, the inflation bias problem is solved through delegation.

Lohmann (1992) showed that the government can do even better if it appoints a weight-conservative central banker but limits the central bank's independence. Rogoff's solution highlights a trade-off; central bank can reduce the inflation bias but only at the cost of distorting stabilization policy. According to the Lohmann (1992), if the aggregate supply shock turns out to be too large, the central banker should respond more actively to large shocks in order to reduce the deadweight loss induced by this distortion. But in normal times, the monetary authority should follow the simple zero-inflation rule.

Walsh (1995) states that, the most convenient way to determine an optimal incentive structure is to assume that the government can offer the head of the central bank a state-contingent wage contract. Such a contract allows one to derive explicitly the manner in which the bank's incentives should depend on the state of the economy, namely output fluctuations and inflation variability. Presenting the central bank with this incentive contract achieves the dual objectives of eliminating the inflationary bias while still ensuring optimal stabilization policy in response to the central bank's private information about the aggregate supply shock. Thus, a state-contingent wage contract for the central banker allows central bank to eliminate the inflationary bias while ensuring optimal stabilization policy.

Nevertheless, there are some other reasons that can cause credibility problem of policy authority other than time inconsistency problem. If policymakers target the normal level of employment, an inflationary bias arises if they are uncertain about economic conditions and are more sensitive to employment below than above normal level. This view implies a positive association between inflation and the variance of output shocks (Cukierman and Gerlach 2003). According to Cukierman and Gerlach (2003), in the absence of a Kydland--Prescott-Barro--Gordon (hereinafter KPBG) type inflation bias, the use of monetary policy to stabilize shocks to the natural level of employment may lead to an inflation bias even if policymakers are satisfied with the potential level of employment so that the KPBG inflation bias is non-existent. Some uncertainty about the future state of the economy and asymmetric concerns about positive and negative output gaps combine to create an inflation bias. This result obtains in spite of the fact that the central bank's desired level of economic activity is equal to potential output or normal employment (Cukierman and Gerlach 2003:543).

Tambakis (2004) states that, when the short-term Phillips curve is nonlinear and convex, the KPBG inflation bias is positive even when monetary policy credibly pre-commits to target the natural rate, the central banks preferences are quadratic and symmetric, and there is no future uncertainty. In a stochastic convex economy, average unemployment is always above the natural rate and is increasing in inflation variability. It follows that average inflation and unemployment move together, the mean inflation rate is higher when inflation is more volatile.

As a result, credibility problem can arise not only from time-inconsistency of optimal plans but also from other reasons, such as uncertainty about the future state of the economy even if

central bank's desired level of economic activity is equal to potential output and the feature of short-term convex Phillips curve in the economy.

Kremers (1990) analyzes Ireland's inflation experience after its participation in European Monetary System (EMS) and concludes that the participation in a fixed but adjustable exchange rate system with a group of low-inflation countries caused inflation expectations to be brought down in Ireland. According to the paper, a semi-fixed exchange rate policy may provide a source of discipline enhancing credibility of disinflation and reduces its detrimental impact (i.e. output loss) on the economy.

Rodriguez et al. (2008) provide an overview of several studies about the credibility of three of the weakest currencies that participated in the EMS (the Spanish peseta, the Portuguese escudo, and the Irish pound), as well as to present a joint analysis of credibility of weak and hard currencies. According to the paper, the Exchange Rate Mechanism (ERM) facilitated the necessary process of disinflation and that it raised the costs of inflation in the EMS. The aim of ERM was to provide discipline to macroeconomic policies that would ensure that fiscal deficits would not be compounded by monetary expansions. In these matters, Germany emerged almost naturally as the anchor for exchange rate and inflation expectations. In fact, the ERM could be seen as an institutional arrangement which has enabled the member countries to borrow the reputation of the Bundesbank by pegging their exchange rates to the Deutschmark. In this way, weaker currencies achieved a greater degree of credibility due to the existence of reputation effects within the ERM. In other words, EU member states with histories of high inflation used the EMS as a way of importing the Bundesbank's anti-inflationary credibility.

3. METHODOLOGY

The major focus of this study is on the responses of inflation to the black market premium shocks, interpreted as credibility shocks, in selected countries. In order to address this question we applied two different econometric techniques. By applying Kalman filter following Agenor and Taylor (1993) we tried to observe credibility of monetary policy by looking at inflation persistence. The key idea of their analysis was to observe credibility of disinflation program in inflation persistence dynamics. However, they use univariate time-series analysis to evaluate credibility effects, which could be difficult to distinguish between changes in the goodness-of-fit of the time-series model generating expectations and changes in the credibility of policy, because potentially relevant variables are excluded from the model. Therefore, we employ Cholesky reduced form panel vector autoregressive (VAR) approach in multivariate context following Pedroni (2008) and Pedroni (2013). This will allow us to analyze the response of inflation to different type of shocks, as well as to calculate variance decomposition. Another advantage also of this technique is that, it excludes fixed country effects from the dynamics and allows among dynamics of individual country responses to be heterogonous among all the countries.

3.1. Kalman Filter technique

Agenor and Taylor (1993) applied Kalman Filter technique to study the credibility effect of the Cruzado Plan implemented in Brazil in 1986. The procedure followed by the authors was based on the existence of the official foreign exchange rate and the black market or parallel exchange rate market in Brazil. The authors' considerations were based on the exchange rate markets. They consider that if a disinflationary program lacks of credibility, agents anticipate the acceleration in the inflation rate.

The model is built on two assumptions: The first assumption is that inflation is, because of inertial forces, a serially correlated process. Expectations play a key role in breaking down inflationary inertia. Moreover, the degree of inflation persistent is assumed to be inversely related to the degree of policy credibility.

The second assumption is related with the definition of an appropriate proxy that is able to measure the degree of credibility of a program, or generally an economic policy that can stabilize the level of inflation. This proxy is given by that part of the parallel market premium, which is orthogonal to movements in the 'market fundamentals'. Parallel market premium is defined as

difference of exchange rates is based on the assumption that it is highly sensitive to market expectations regarding government policies, and therefore, is considered a good variable for examining credibility effects. The idea is to consider how the spread given by the change in the two exchange rates to an announced stabilization program. Hence, we assume that the black market exchange rates are highly sensitive to the change in credibility. Since the parallel market premium is influenced by the private agents' expectations regarding current and future economic policies, the analysis of its behavior is crucial to the study of credibility factors which are affected by changes in expectations. The market premium, that is the difference between official and black market exchange rates, is an endogenous variable. This means that its level will also reflect the behavior of market fundamentals, such as economic growth, past domestic inflation, money growth etc.

If movements in the parallel premium cannot be explained by movements in the market fundamentals, such as economic growth, past domestic inflation, money growth, then the remaining variation must be due to variation in the perceived degree of policy credibility. In other words, all the variations in that part of the parallel market will be strongly influenced by the level of reputation and credibility gained by the authorities.

The model can be divided into two parts. The first part consists of decomposing the parallel market premium (ρ_t) into two components: the 'fundamental component' and 'non fundamental component' which will be the basis for a measure of credibility. The fundamental component of parallel market premium reflects the behavior of market fundamentals. Non fundamental component of parallel market premium, which is orthogonal to movements in the fundamental component, will be heavily influenced by perceptions of policy credibility so that it can be used as an index of credibility.

If we denote parallel market premium (ρ_t) and predetermined fundamental factors (z_t), the general form of the model is as follows:

$$a(L)\rho_t = b(L)z_t + u_t \quad (1)$$

$$a(L) = 1 + a_1 L + a_2 L^2 + a_3 L^3 + \ldots + a_k L^k \quad (2)$$

$$b(L) = b_1 L + b_2 L^2 + b_3 L^3 + \ldots + b_k L^k \quad (3)$$

Where a_t represents a scalar coefficient, the b_t denotes conformable coefficient vectors, *L* is the lag operator, and u_t the residual process. After rearranging we get:

$$\rho_t = a_1 \rho_{t-1} + \ldots + a_k \rho_{t-k} + b_1 z_{t-1} + \ldots + b_k z_{t-k} + u_t \qquad (4)$$

Equation (4) can be interpreted as the first equation in a vector autoregressive system for parallel market premium. The residuals from the equation (4) we derive our credibility shocks (c_t).[2] We believe that such a specification captures the agents' beliefs about monetary policy. It is assumed to be the complement of the error term u_t :

$$c_t = -u_t \qquad (5)$$

In addition, it could reasonable to argue that intercept of ARDL[3] system from equation (4) can be interpreted as an average level of CB credibility. In fact, time invariant intercept is an average level of market premia conditional on the past information of fundamental. We will use it to explain the reason of variations in credibility across countries.

In the second part of the model, using a Kalman filter approach, a backward-looking[4] process for inflation with parameters varying with non-fundamental component of the parallel market premium are estimated. Harvey (1989) argues that the key to handling structural time series models is the state space form, with the state of the system representing the various unobserved components such as trends and seasonal. Once in the state space form, the Kalman filter provides the means of updating the state as new observations become available. Assuming that inflation, π_t , is given by a AR(1) process, the system to be estimated is given by

$$\pi_t = \alpha_t \pi_{t-1} + \varepsilon_t \qquad (6)$$

$$\alpha_t = \alpha_{t-1} + \gamma c_t + \vartheta_t \qquad (7)$$

Where (6) is the measurement equation with π_t and ε_t are (*nx1*) vectors and (7) is the transition equation. α_t and ϑ_t (*nx1*) are vectors and is a c_t (*nx1*) matrix. It is assumed that all

[2] Agenor and Taylor (1992) expressed c_t as a credibility variable. However, due to presence of stochastic characteristics it can be considered as shocks rather than variable.
[3] We omitted from the equation (4) for simplicity.
[4] As Strum (2009) showed that forward-looking model is better in price-level targeting models than forward-looking models. Since, in our sample (198Q1-1998Q4) many of the countries was adopting between fixed and heavily managed exchange rate regimes, this consistent with Strum (2009) argument.

errors are normally distributed and $E(\varepsilon_t \vartheta_t)=0$ for all t. Equations (6) and (7) represent a state space form.

Finally, following the theory of Agenor and Taylor (1993) the Kalman filter recursions can then be applied to yield optimal estimates of the state variable sequence α_t . The resulting estimate of γ should be negative: the higher credibility is, the lower the inertial effect on inflation. The coefficient α_t of the equation (7) should be smaller after the accomplishment of a credible disinflation program.

Note that, this method seems suitable for low and moderate inflation, whose series normally are stationary. However, high and chronic inflation series tend to be non-stationary due to a higher degree of persistence. This being the case such a method can lead to inconsistent coefficient estimates.

3.2. Reduced Form Panel VAR

Due to univariate structure of Kalman Filter technique in Agenor and Taylor methodology makes difficult to distinguish between changes in the goodness-of-fit of the time-series model generating expectations and changes in the credibility of policy. By applying Cholesky reduced form panel vector autoregressive (VAR) following Pedroni (2008) and Pedroni (2013) we expect to overcome this problem. In a sense that it will allow us to analyze inflation persistence in terms of different type of shocks, particularly to observe whether credibility shocks differ from inflation shocks.

Hence, the following questions would be relevant to answer: How much credibility shock differ from inflation shock? How much credibility shock explains endogenous variations in inflation? These questions are the main reasons for employing panel VAR analysis.

During 1980 and 1990 world experienced some important structural changes in macroeconomic level as well as in monetary policy. These changes were regional as well as global. It is important to take into consideration the fact that individual countries are likely to be linked cross-sectional via common global and regional shocks. Therefore, heterogeneity exists in monetary policies during this period. The presence of heterogeneity makes conventional dynamic panel methods not appropriate, due to fact that they require the dynamics of individual country responses to be identical among all countries. For the second part of paper we used the Cholesky reduced form VAR methodology developed in Pedroni (2008) and Pedroni (2013).

The VAR model is then given by the following system of equations:[5]

$$\Delta z_t = \Gamma_0 + \sum_{i=1}^{p_i} \Gamma_i \, \Delta z_{t-i} + \mu_t$$

Where $\Delta z_t = (\Delta p_t \; \Delta g_t \; \Delta m_t \; \Delta r_t)'$ matrix of endogenous variables premium, output growth, money growth and inflation[6]; Γ_0 is a matrix of constants, $\mu_t = (\mu_{pt} \;\; \mu_{gt} \;\; \mu_{mt} \;\; \mu_{it})'$ matrix of innovations to premium, output growth, money growth and to inflation respectively, with $E(\mu_t) = 0$, and covariance matrix $E(\mu_t \mu_s') = \Omega_\mu$. Thus, a vector autoregression is a system in which each variable is expressed as a function of own lags as well as lags of each of the other variables. To get orthogonalized impulse response and variance decomposition we applied Cholesky decomposition (triangularization) $\Omega_\mu = LL'$, where L is known as the Cholesky decomposition matrix for Ω_μ, and then accumulated the impulse responses to see the effects of the shocks on the levels of the variables[7]. A key quantity for our analysis is the cumulative impulse response function (IRF). An IRF measures the time profile of the effect of perturbations on the expected future values of variables in a dynamical system. The advantages of using this approach is that, with panel data we can control for factors that could cause omitted variable bias if they are omitted, also we can control unobserved or unmeasured unobserved heterogeneity.

3.3. Data description

The most the quarterly data for Kalman Filter and panel VAR estimation taken from International Financial Statistics of the IMF over the period from 1980 to 1998 years.[8] The countries are chosen based on availability of quarterly data, finally we could estimate just for 20 countries.[9] The list of countries and time periods used in the study is provided in the appendix.

The variables which we refer to market fundamentals are Real GDP, M1[10] Money aggregate, Consumer Price Index (CPI).[11]

Parallel market premium is a main indicator for measuring credibility, and calculated as a

[5] To choose lag length for reduced form VAR we used Akaike's Information Criteria (AIC).
[6] We used the same market fundamentals as Kalman Filter technique.
[7] See Pedroni (2008) and Pedroni (2013) for details on the identification and computation of the impulse response form and the decomposition of shocks into regional versus national in panels.
[8] See more detail in Table 4 in Appendix.
[9] Australia, Austria, Brazil, Canada, Chile, Denmark, France, Italy, Japan, Korea, Mexico, Netherland, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Turkey.
[10] For some countries due to absence of M1 money aggregate instead we used M2 or M3.
[11] See data description Appendix B table 5.

difference between logarithmic black and official exchange. The reason for calculation of premium in a way is to avoid minus signs in premium.[12] The data on black market and official exchange rate taken from Carmen Reinhart's web-site.

Central Bank Independence Index taken from Arnone et al. (2007). They combined two studies of Cuckierman(1992) and Grilli, Masciandaro and Tabellini (1991). Their study provides three type of Independence index: Political Independence, Economic Independence and Overall Independence. In our analysis we used all three types of indices.

[12] The negative sign of premium can be seen confusing. One of the reasonable explanation for that, a negative premium may have emerged during periods when commercial banks have been forbidden to buy foreign currency without properly identification of the seller; in such circumstances, a negative premium represents a "laundering charge" (Dornbusch et al. 1983)

4. EMPIRICAL RESULTS

This section addresses stationary issues for both of the techniques. The stationary condition is required for ARDL system, which is the first step of Agenor and Taylor (1993) methodology. The stationary condition for all the variables has been tested, and founded that almost all of the variables a highly statistically stationary from the first order, however CPI is found to be *I(2)* (see Appendix Table 1).

Explaining spread between exchange rates conditional on fundamentals only makes sense when they are not cointegrated. If the CB sets exchange rate in a response to the market, then they are might be cointegrated. There are can be several examples of CB responses such as devaluating official exchange rate in order to promote export, or even CB can actively participate in emergence of black market in order to sell foreign currencies to finance budget deficits. But if CB sets exchange rate regardless what the market is doing, than it is basically policy variable that CB takes the value whichever it wants, and therefore is not necessarily that official exchange rate cointegrated with black market exchange rate. In order series to be cointegrated they have to follow unit root process. *Table 2* in *Appendix* shows the results of panel unit root test for each black market and official exchange rate. Under the null hypothesis of unit root the results show that the series are stationary, suggesting that there is no cointegration between two variables.

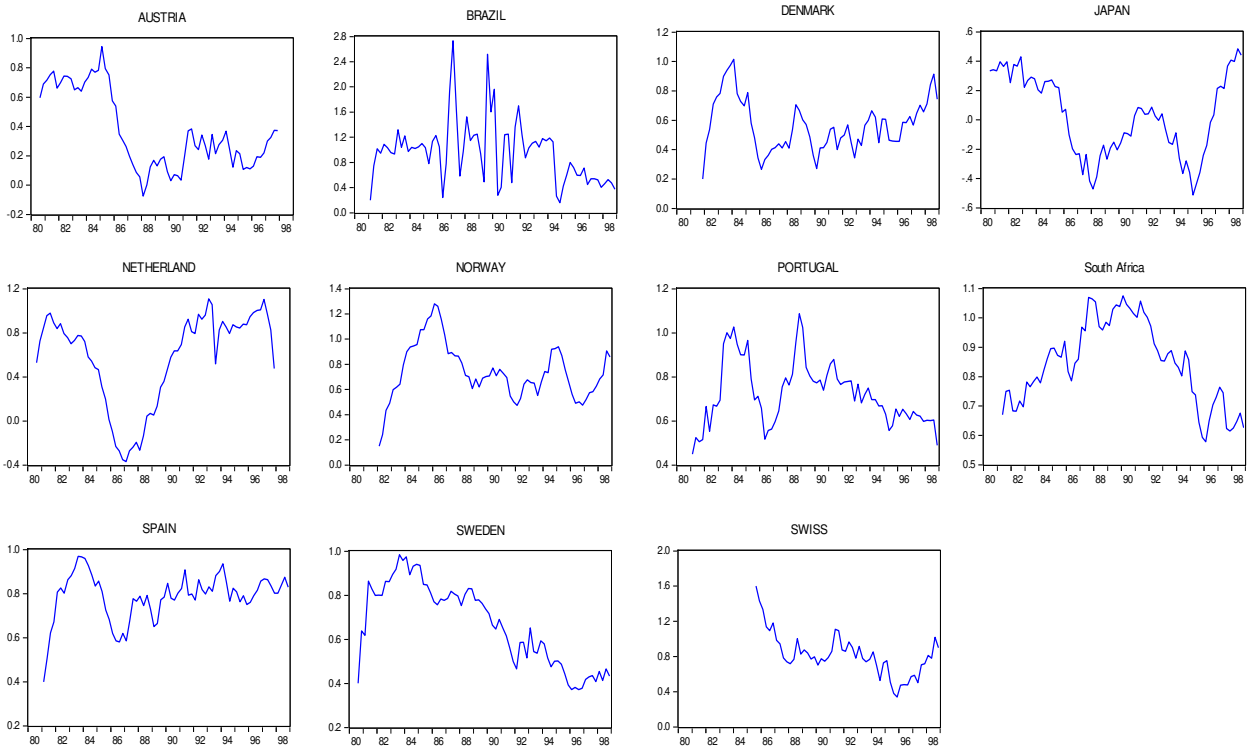
4.1. Kalman Filter

Following Agenor and Taylor (1993) methodology we performed first and second ARDL systems for 20 countries to derive residuals from equation (4) and to use as a proxy for credibility shock c_t.

The second part of the model is to estimate a backward-looking process for inflation with parameters varying with the non-fundamental component of the parallel market premium, using Kalman filter approach. The coefficient of credibility variable γ from equation (7) is negative, as predicted by the model, and statistically significant only for Austria, Brazil, Denmark, Japan, Netherland, Norway, Portugal, South Africa, Spain, Sweden, and Switzerland (See Appendix *Table 3*). *Fig 1* shows the behavior of the coefficient α_t for countries for which γ gamma coefficient has been found statistically significant. In general, figure 1 depict that backward-looking expectations in the most countries are likely to decline over the time. In fact, the persistence effect in the most of the countries declined dramatically starting from the end of 1984

until 1986 and 1988. However, after 1988 we can observe modest increase in persistence effect in most of the countries, significantly for Netherland, Portugal, Brazil. Note that, the nine out of eleven countries are OECD countries. Therefore, it is consistent with fact that, the broad stability of nominal non-oil commodity prices and the sharp declines in real prices from 1984 to early 1987 contributed to further disinflation in the OECD area and caused to inflation expectations to decline (Coe, Durand and Stiehler,1990). Therefore, these suspicious results motivated us to employ the panel VAR analysis to address similar question: whether decline in inflation persistence due to increase in monetary policy credibility or due to another reason.

Figure 1: Inflation persistence, dynamics of α_t coefficient.

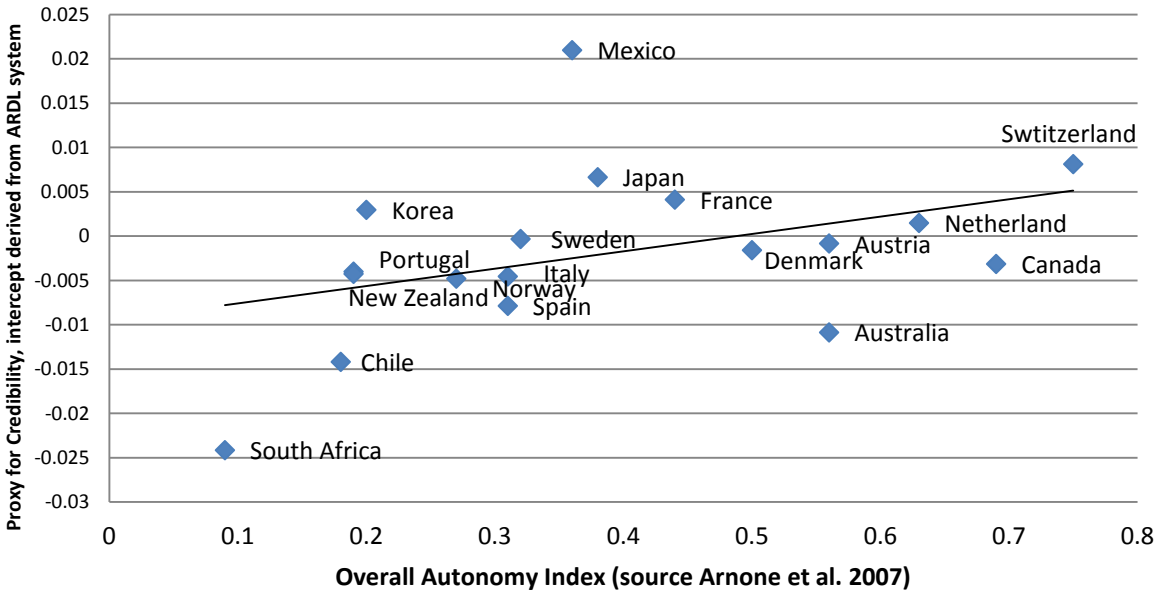


Finally, in order to explain the reason for variations in average credibility across countries we plot intercept from ARDL system, interpreted as average level of credibility, and Central Bank Autonomy index (Arnone et al., 2007) in figure 2. We found positive correlation between Central Bank Autonomy (Overall) and average level of credibility, indicating that, the more Autonomy the more credible Central bank policy will be.

Our conclusion from Kalman Filter analysis is that, inflation persistence declined over the time due to credible monetary policy. However, taking into account disinflation periods also

associated with other macroeconomic improvements, which can effect positively to disinflation process, it is hard to argue that, persistence effect declined only due to credible monetary policy. Therefore, following Pedroni (2008) and Pedroni (2013) we applied panel VAR analysis to disentangle the inflation, credibility and monetary policy shocks.

Figure 2. Central Bank Autonomy and Credibility



3.2. Reduced form Panel VAR results

Reduced form panel VAR applied to answer the following questions: (i) what is the median response of the inflation rate to a country –specific premium shock? (ii) How the responses of inflation due to premium shocks differ from premium shock? (iii) How much cross-country variation is there in this response? (iv) What factors determine the response of the inflation to credibility shocks across countries?

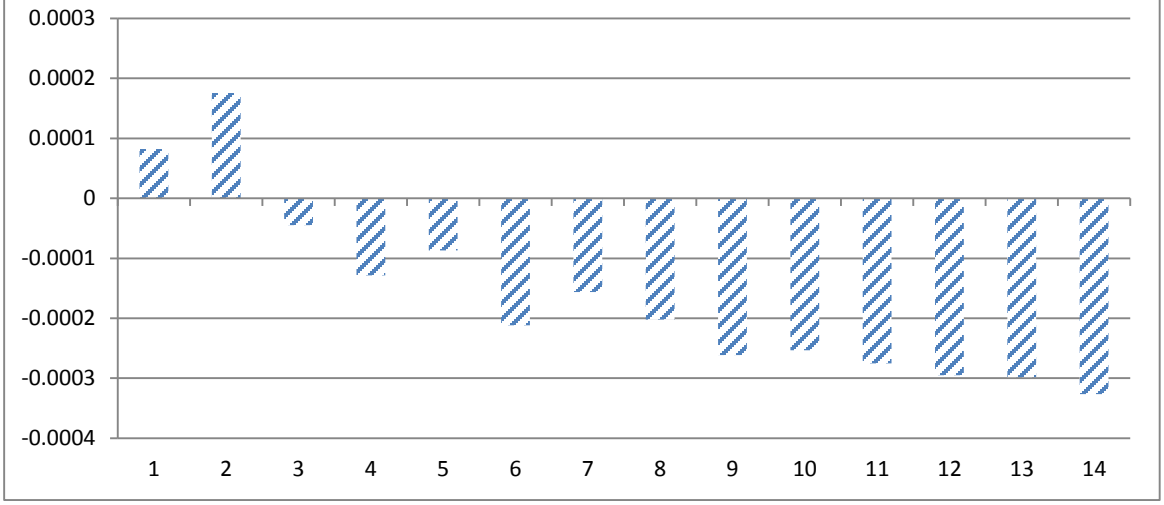
3.2.1. Impulse responses and variance decomposition

In this section we in particular we are interested in response of inflation to credibility shock as well as monetary policy and inflation shock. *Figure 3* and *4* reports impulse responses of inflation due to premium shocks in higher and lower income[13] countries respectively. The main

[13] Grouping the countries by Higher and lower income based on level of GDP per capita income. In particular the countries with lower than 15,000 $ GDP per capita at least in half of the time span considered as lower income countries, otherwise higher income countries. Lower income countries are

conclusion from *figure 3* is that, premium shock, interpreted possible credibility shock, on average reduces inflation in higher income countries.

Figure 3: Predicted Impulse Responses In higher Income Countries



In lower income countries, however, premium shocks cause to increase inflation as depicted in *figure 4*. Moreover, in 1st quarter there is a reduction in inflation, then inflation dramatically increases, that is, credibility shock doesn't cause to reduce inflation even causes to increase, reflecting the explosive behavior of prices when policy credibility is low. Initial reduction can be explained by several hypotheses such as temporariness hypothesis, sticky prices etc.[14]

Brazil, Chile, Korea, Mexico, Portugal, South Africa, Spain and Turkey. Whereas higher income countries are Austria, Australia, Canada, Denmark, France, Italy, Japan, Netherland, New Zealand, Norway, Sweden and Switzerland.

[14] In more detail for this phenomenon see Rebelo and Vegh (1997)

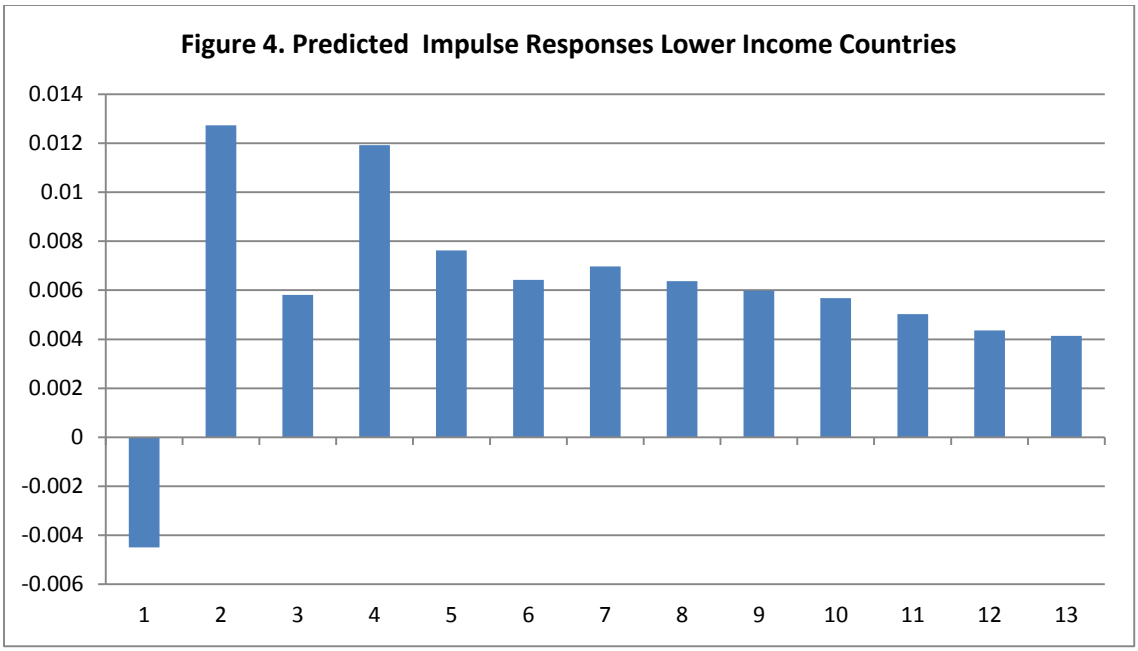
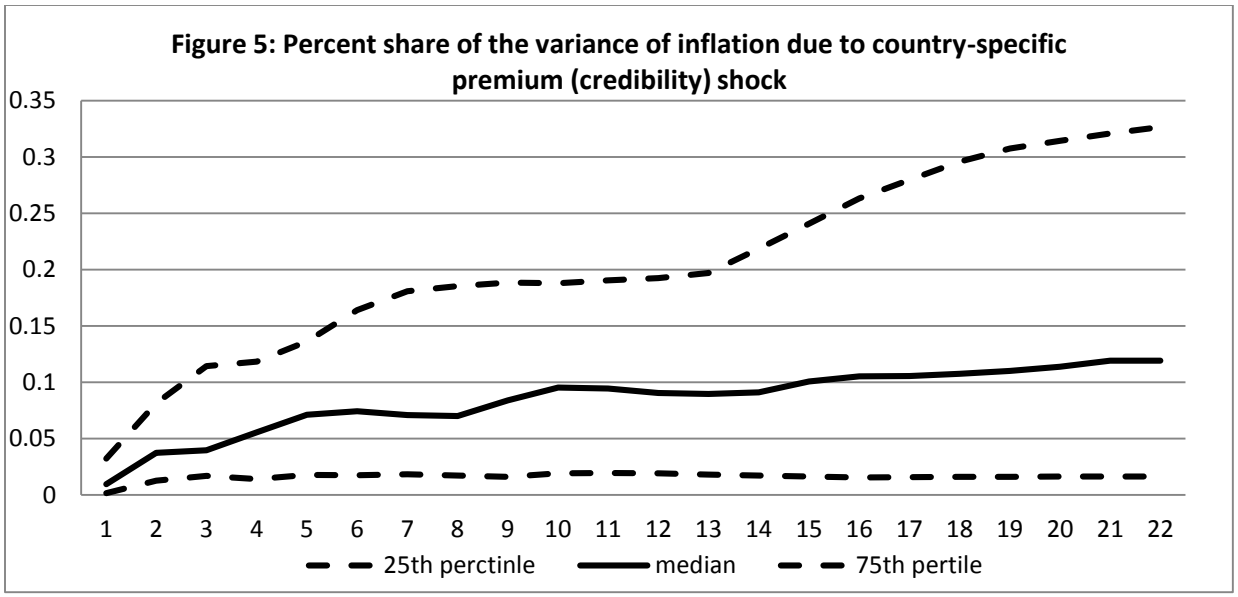


Figure 5 reports the median as well as the 25th and 75th percentile fractions of the variance in the inflation rate that is explained by the credibility shocks. On average, country specific credibility shocks explain about 8-10% of the variation in the inflation over 22 periods. Another point is that, there is significant variation across countries. Thus, in the 1st quarter variation ranges from close to 0 to 5 percent, in the 22 quarters response period ranges from 2% to 33%.[15]

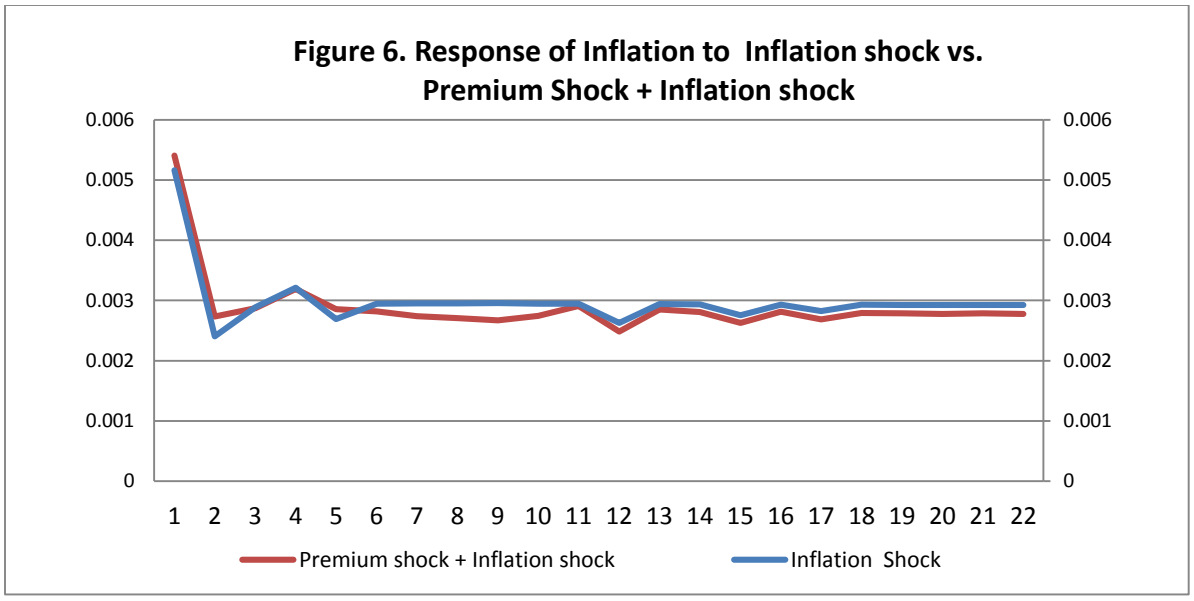
[15] The impulse responses and variance decompositions for all the other variables in the system are provided in the Appendix C (Figure C1 and C2)



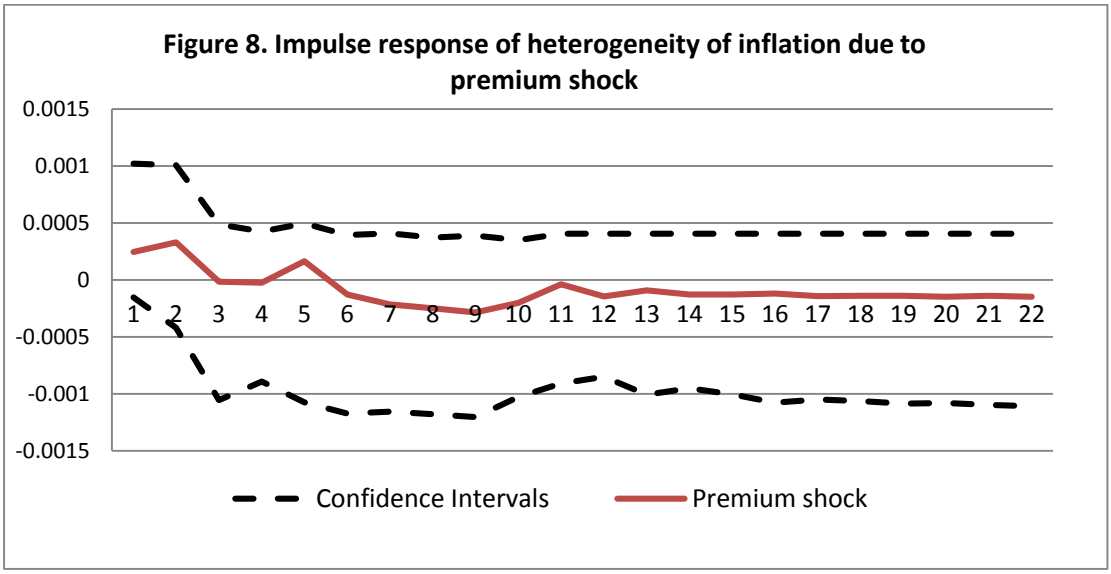
3.2.2. Comparison of the shocks

In this subsection we analyze the response of inflation to different type of shocks. Particularly we are interested how much response of inflation to credibility shocks differs from change in inflation shock or monetary policy shock. *Figure 6*, shows that response of inflation to inflation shock[16] and combination of change in inflation shock and premium shock are not significantly different, that is, the effects starts and ends in the same period of time, but has a bigger transitory peak response, presumably due to the expectation effect of the credibility shock. However, these results are not consistent with Kalman Filter results, in a sense that, VAR analysis shows that credibility shocks are not different from inflation shocks.

[16] Impulse response of inflation with confidence intervals depicted in Appendix A, *Figure 7.*



Impulse responses of inflation due to credibility shock are depicted in *figure 8*. The graph shows that impulse responses are statistically insignificant. However, results are mainly due to fact that, impulse responses of some countries are negative while others positive, in other word the graph shows heterogeneity among impulse responses of the countries.[17]



3.2.3. Variation across countries in impulse responses

Another central question could be what are the reasons cross-country variations of responses of inflation due to premium shocks? To answer this question, we examined the role of

[17] In fact, bootstrapping method applied to build confidence interval for each countries impulse responses, and founded that, impulse responses are significant for most of the countries.

specific country characteristics to explain the cross-country pattern in the responses of inflation to credibility shocks.

In particular we tried to test hypothesis that central bank autonomy the main determinant of credibility of monetary policy (Cukierman, 1992; Walsh, 1994). We used three kind of central bank autonomy indicator developed by Arnone et al. (2007) political autonomy, economic autonomy and overall autonomy. The results depicted in figure 5a-5c. Each figure has six plots showing the bivariate relationship between the six impulse responses (four quarters, average and the minimum). The main rationale about central autonomy hypothesis is that, the more central bank has independence the more credible will be monetary policy, thus lower inflation rate. Findings show that, in overall there is negative correlation between central bank autonomy and impulse responses, depicted in figure 2a. However, when we disentangle the autonomy to political and economic autonomy, we found slightly different results. For first quarter response political autonomy plays more roles in reduction inflation. In second and third quarters' the effects are not different significantly in both type of autonomy. We need to notice that this shows more correlation rather than causation. Moreover, due to lack of sufficient number of countries it is hard to argue that these variations in the impulse responses across countries are systematic.

5. CONCLUSION

Despite the abundance of empirical paper on black market exchange rate dynamics, only few studies emphasized relationship between central bank credibility and black market exchange rate premia in empirical context. The major goal of this study was analyze the effect of "credibility" shocks to the dynamics of inflation persistence in 20 countries using quarterly data for the period 1980-1998. We employed two econometric techniques: Kalman Filter methodology following Agenor and Taylor (1992), and panel VAR approach following Pedroni (2008) and Pedroni (2013).

Our conclusion form Kalman Filter analyses is that, inflation persistence has declined for the overtime due to credible monetary policy. However, from panel VAR analysis we found different results. Impulse response analyses show that inflation does not respond significantly to premium shock compared to inflation shock. In that sense, the results of panel VAR analysis are not consistent with Kalman Filter technique following Agenor and Taylor (1993) methodology. The reason for that could be due to univariate structure of the model in Kalman Filter methodology.

Thus, it could be difficult to distinguish between changes in the goodness-of-fit of the time-series model generating expectations and changes in the credibility of policy, because potentially relevant variables are excluded from the model. In contrast multivariate structure panel VAR approach allows us to build model conditional on past values of inflation.

Moreover, we also found some evidence that CB independence could be important institutional reform to increase credibility of monetary policy.

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APPENDIX A

Table 1 : Unit Root Test Results (ADF)

Variables	Countries	In the Level		In the difference	
		Trend	Actual value	Trend	Actual value
Parallel Market Premium	*Australia*		-5.358417***		
	Austria		-6.111163***		
	Brazil		-2.884532*		
	Canada		-4.775068***		
	Chile		-2.942980		-7.323494***
	Denmark		-4.701050**		
	France		-2.364190		-9.468905***
	Italy		-2.873819*		
	Japan		-6.749618***		
	Korea		-4.350478**		
	Mexico		-4.478148**		
	Netherland		-4.787664***		
	New-Zealand		-3.771604**		
	Norway		-5.888806***		
	Portugal		-3.755724**		
	South Africa		-3.718003**		
	Spain		-1.857663		-9.351654***
	Sweden		-4.211596**		
	Switzerland		-4.129660**		
	Turkey		-4.483149***		
CPI	*Australia*		-1.995094	yes	-3.234399**
	Austria		-1.627267		-5.721135***
	Brazil		-0.317080		-2.901407 **
	Canada	yes	-1.517252	yes	-4.978334***
	Chile		-2.241446	yes	-5.907617***
	Denmark	yes	-4.003842***	yes	-7.657631
	France			yes	-3.621430**
	Italy			yes	-3.046197**
	Japan			yes	-3.264668**
	Korea			yes	-5.858173***
	Mexico			yes	-3.357530*
	Netherland			yes	-2.315976
	New-Zealand	yes	0.292493	yes	-4.830880
	Norway			yes	-7.044517***
	Portugal			yes	-3.409941*
	Portugal			yes	-3.409941*
	South Africa			yes	-6.674167***

	Spain			yes	-2.306936
	Sweden		-1.826437	yes	-4.955740
	Switzerland			yes	-1.762769
	Turkey			yes	-10.15641***
M2	*Australia*		4.472538		-2.547894*
	Austria		2.824197		-7.121691***
	Brazil		1.613373		-4.225407**
	Canada		-1.735049		-5.398428***
	Chile		0.888847		-7.583921***
	Denmark		-0.746546		-8.568184***
	France		-1.811186		-6.531582***
	Italy		-1.241890		-7.317039***
	Japan		3.931652		-3.483846**
	Korea		1.084913		-8.247630***
	Mexico		1.678208		-3.167133**
	Netherland		-0.519123		-8.579485***
	New-Zealand		0.688815		-5.626185***
	Norway		0.300968		-9.941589***
	Portugal		1.663842		-6.607955***
	South Africa		5.541025		1.05207*
	Spain		2.245019		-2.321617**
	Sweden		1.054487		-8.860800***
	Switzerland		-0.118435		-4.198164***
	Turkey		2.435724		-2.040976
GDP	*Australia*	yes	2.875432		-6.509464***
	Austria	yes	1.228246		-9.427109***
	Brazil	yes	-0.192542		-10.43885***
	Canada	yes	-0.228367		-4.230944***
	Chile	yes	0.701638		-7.990145***
	Denmark	yes	0.314195		-8.866857***
	France	yes	0.620526		-6.804963***
	Italy	yes	0.030066		-8.092096***
	Japan	yes	-1.929288		-2.842870**
	Korea	yes	-0.188234		-6.111443***
	Mexico	yes	0.365206		-6.264288***
	Netherland	yes	2.746825		-7.901333***
	New Zealand	yes	-0.333415		-9.686997***
	Norway	yes	1.437692		-12.07066***
	Portugal	yes	1.589725		-11.51867***
	South Africa	yes	-0.561012		-4.485468**

	Spain	yes	0.090432		-2.656618**
	Sweden	yes	0.738013		-12.28401***
	Switzerland	yes	-1.420578		-5.326300***
	Turkey	yes	-0.278718		-7.721464***

Table 2: Panel Unit Root Test

Variables	# of Countries	Panel Unit Root test			
		Levin-Lin			Im-Pesaran-Shin
		Rho-stat	t-rho-stat	ADF-stat	ADF-stat
Black Market exchange rate	20	-4.00	-1.79	-1.25	-1.82
Official Exchange rate	20	-3.17	-1.87	-0.83	-0.92
Notes: Variables test in logarithms. The tests are based on Pedroni (1999, 2004) and test statistics a normally distributed.					

Table 3: Statistical results for credibility variable.

Country	**Coefficient**	**Stand. Error**	**Prob**
Australia	**-4.750416**	**5.508526**	**0.3885**
Austria	**-7.256333****	**0.293844**	**0.0427**
Brazil	-1.649216***	0.345909	0.0000
Canada	-8.090274	17.24283	0.6389
Chile	-0.447057	2.815038	0.8738
Denmark	-9.596492*	4.904062	0.0504
France	-0.793646	4.174737	0.8492
Italy	-2.698765	5.682623	0.6348
Japan	-7.557352*	4.045325	0.0617
Korea	-3.729321	3.335928	0.2636
Mexico	-1.218541	2.051466	0.5525
Netherlands	-4.880586*	2.943818	0.0973
New Zealand	-1.856738	6.695094	0.6982
Norway	-3.046939**	1.368755	0.0260
Portugal	-2.492947**	1.076437	0.0206
South Africa	-1.280133**	0.570541	0.0249
Spain	-3.851798**	1.688165	0.0225
Sweden	-3.470358**	1.489922	0.0198
Switzerland	-10.78241**	4.265110	0.0115
Turkey	-0.531808	2.428126	0.8266

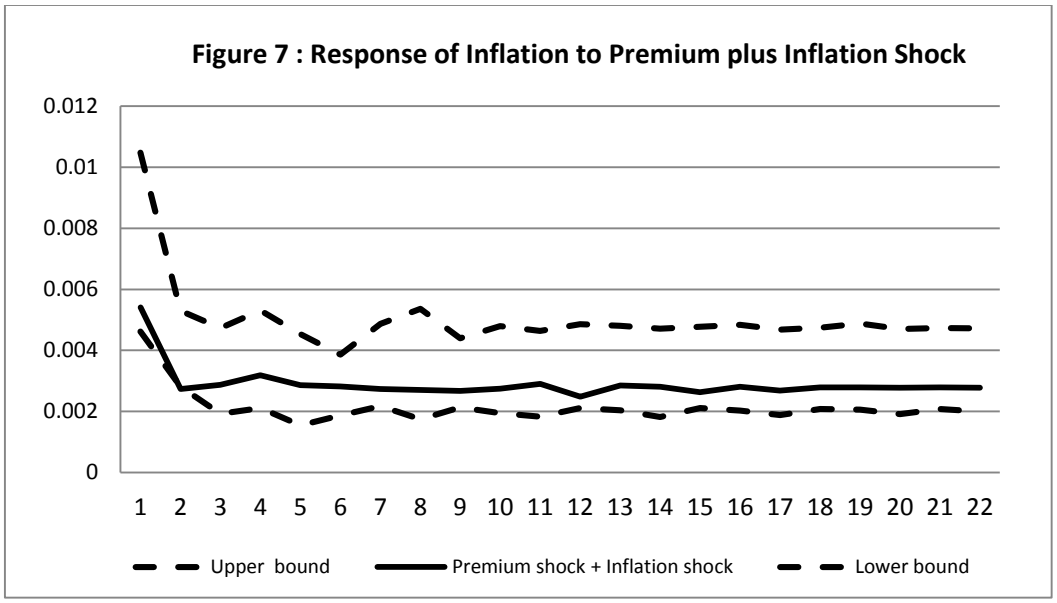


Figure 9 a. Impulse Responses of inflation (due to premium shocks) and Overall C.B. Autonomy

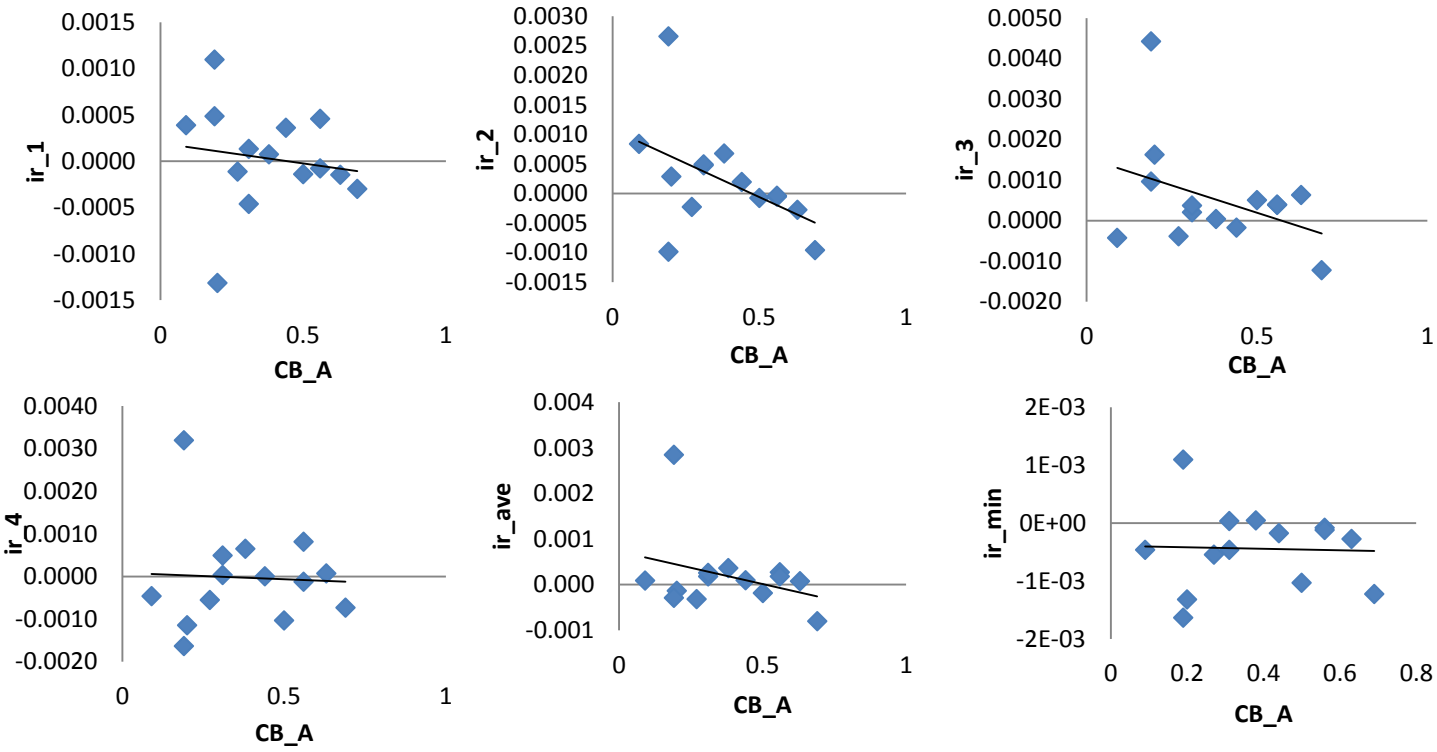


Figure 9b. Impulse Responses of inflation (due to premium shocks) and C.B. Economic Autonomy

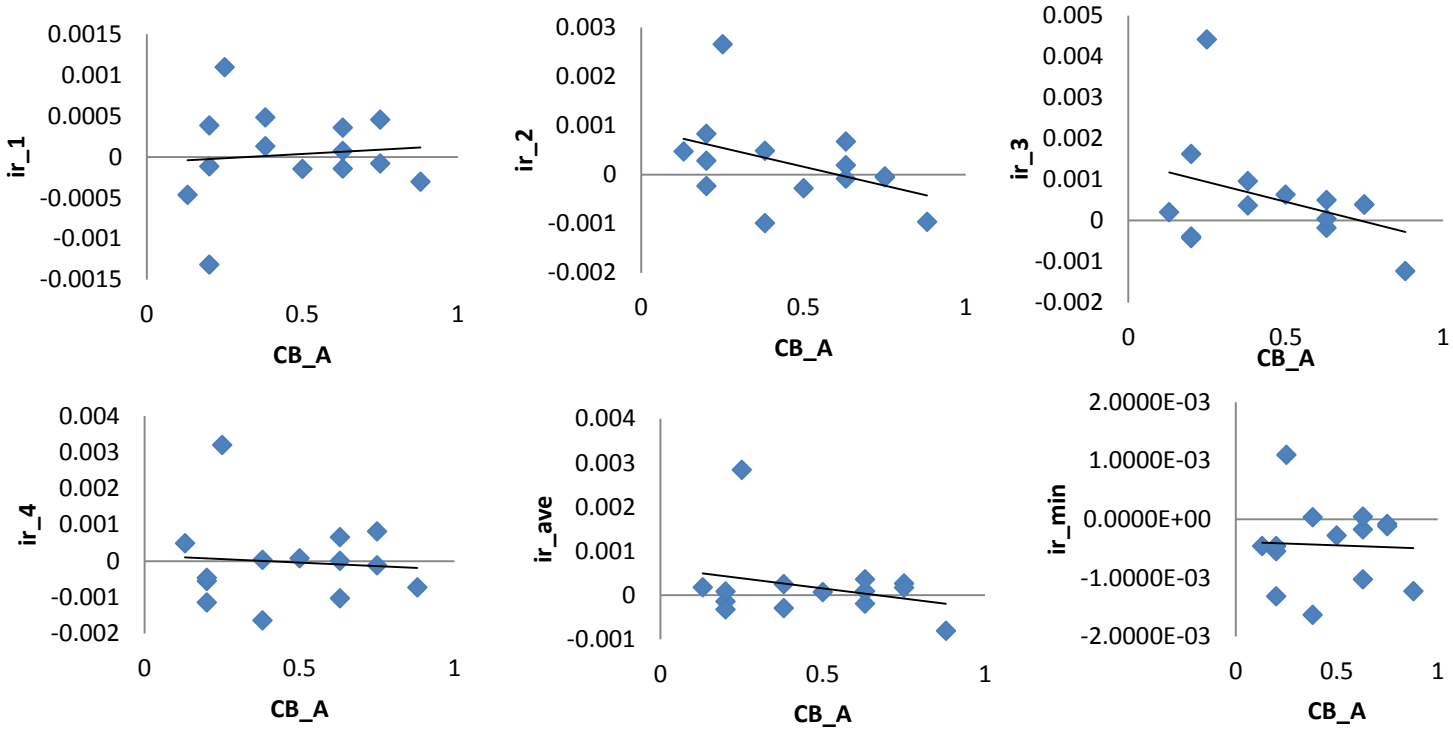
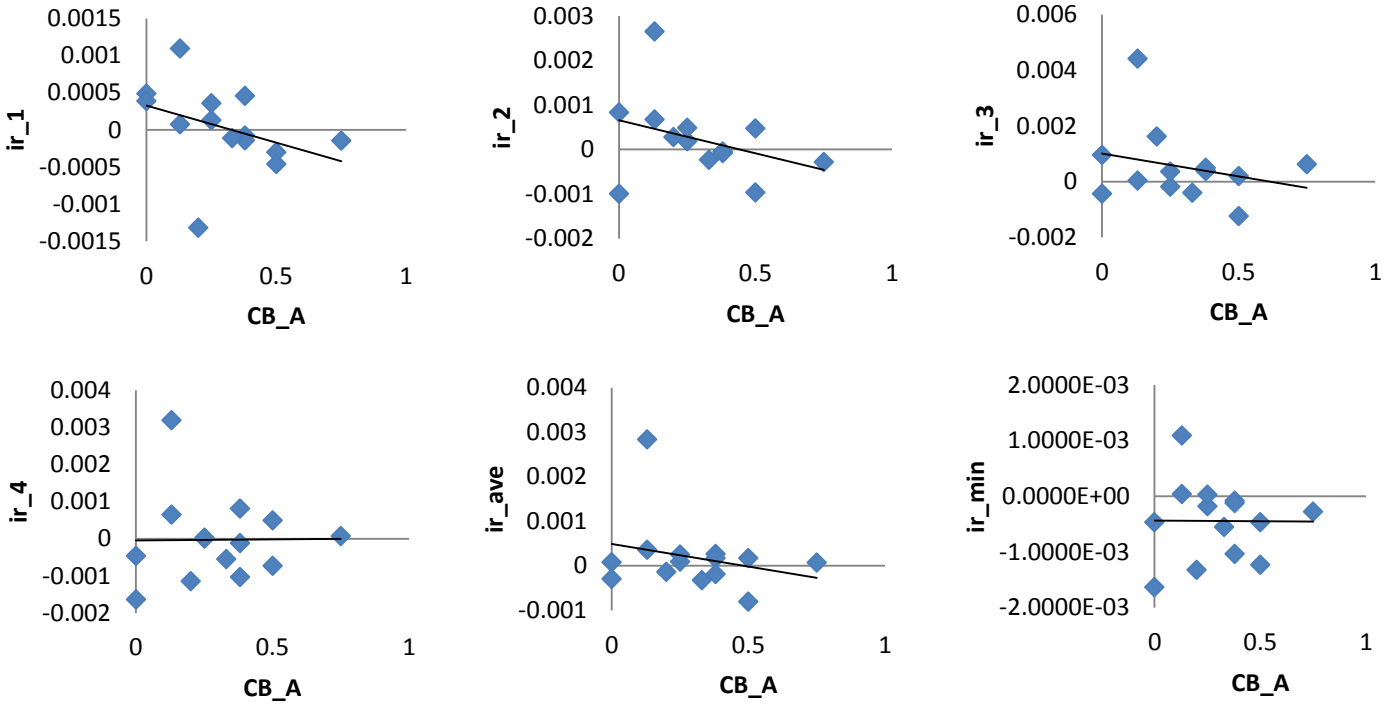


Figure 9c. Impulse Responses of inflation (due to premium shocks) and C.B. Political



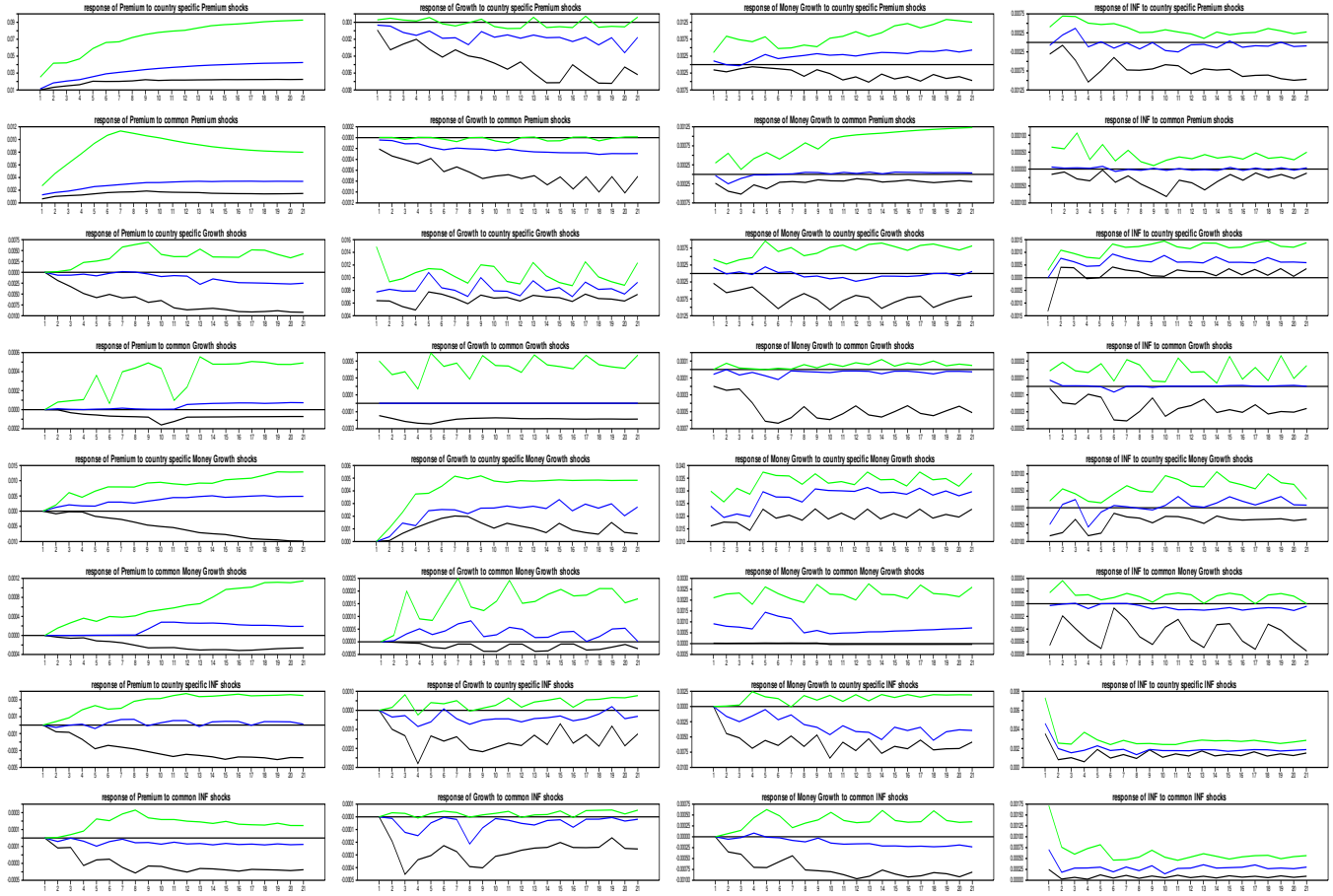
Appendix B.

Table 5. Sample Coverage			
Country name	**WB code**	**Start time**	**End time**
Austrlia	AUS	1980q1	1998q4
Austria	AUT	1980q1	1998q4
Brazil	BRA	1980q1	1998q4
Canada	CAN	1980q1	1998q4
Chile	CHL	1980q1	1998q4
Denmark	DNK	1980q1	1998q4
France	FRA	1980q1	1998q4
Italy	ITA	1980q1	1998q4
Japan	JPN	1980q1	1998q4
Korea	KOR	1980q1	1998q4
Mexico	MEX	1980q1	1998q4
Netherland	NLD	1980q1	1998q4
New Zealand	NZL	1980q1	1998q4
Norway	NOR	1980q1	1998q4
Portugal	PRT	1980q1	1998q4
South Africa	ZAF	1980q1	1998q4
Spain	ESP	1980q1	1998q4
Sweden	SWE	1980q1	1998q4
Switzerland	CHE	1980q1	1998q4
Turkey	TUR	1980q1	1998q4

Table 6. Table Data Sources	
Vairable	**Data Source**
M1 (Zew Zealand)	Federal Reserve New Zealand
M1 (for all other countries)	IFS
CPI	IFS
GDP	IFS
Official and Black Market exchnage rates	Carmen Reinhart Web-site http://www.carmenreinhart.com/user_uploads/data/33_data.xls
Central Bank Indepedence Index	Cuckierman (2004)

Credibility Impulse Responses

reduced form VAR: [Premium, Growth, Money Growth, INF]` = A(0)*[Premium, Growth, Money Growth, INF]`



Appendix C.
Figure C1.

Credibility Variance Decompositions

reduced form VAR: [Premium, Growth, Money Growth, INF]` = A(0)*[Premium, Growth, Money Growth, INF]`

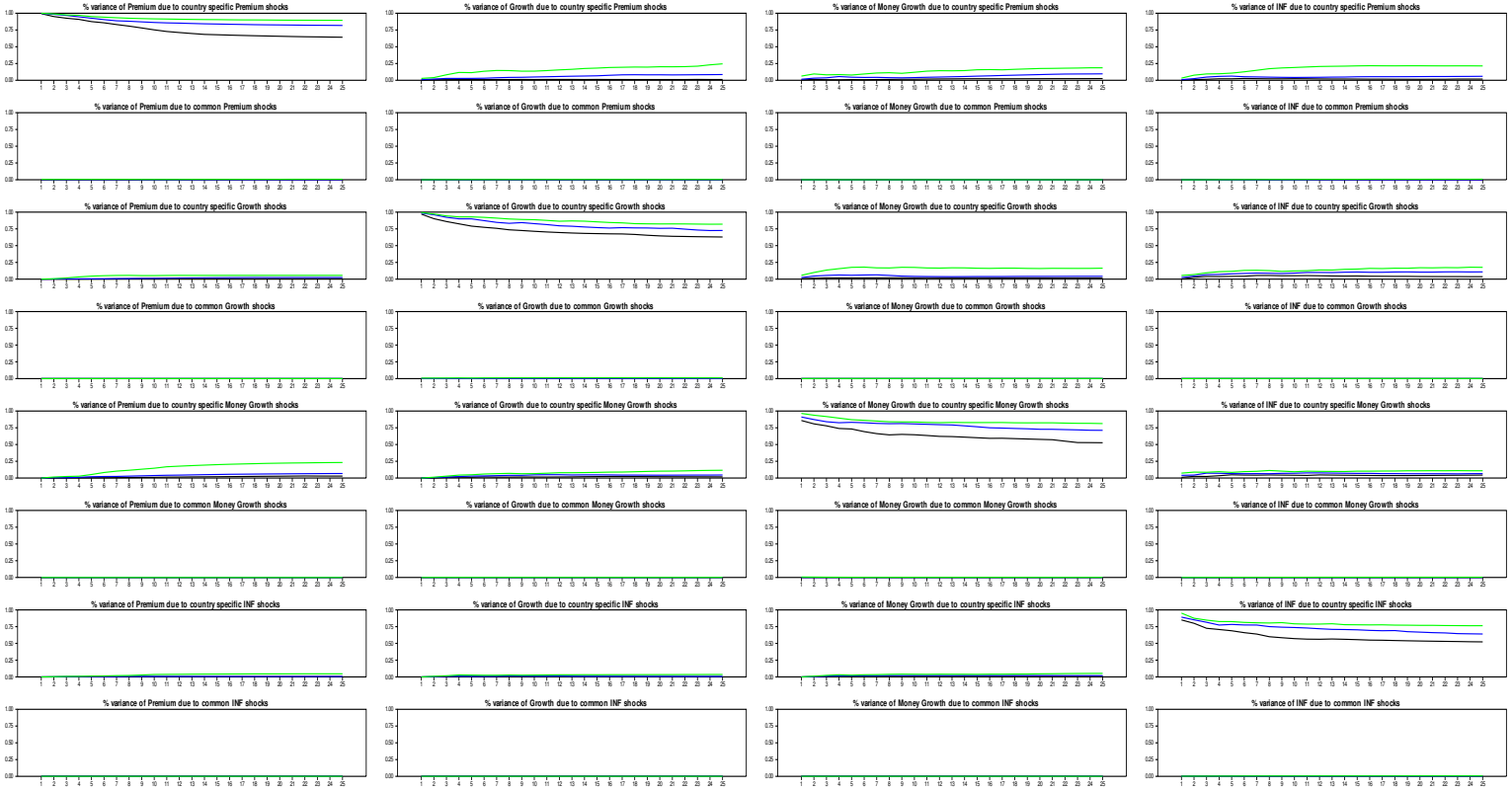


Figure C2.