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Commodity Price Shocks and Imperfectly Credible Macroeconomic Policies in Commodity-Exporting Small Open Economies

Juan Pablo Medina and Claudio Soto

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**Commodity Price Shocks and Imperfectly Credible Macroeconomic Policies in
Commodity-Exporting Small Open Economies**

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Abstract

In this paper, we analyze how lack of credibility and transparency of monetary and fiscal policies undermines the effectiveness of macroeconomic policies to isolate the economy from commodity price fluctuations. We develop a general equilibrium model for a commodity-exporting economy where macro policies are conducted through rules. We show that the responses of output, aggregate demand, and inflation to an increase in commodity price are magnified when these rules are imperfectly credible and lack transparency. If policies are imperfectly credible, then transparency helps private agents to learn the systematic behavior of the authorities, reducing the effects of commodity prices shocks. Coherent with the model, we show cross-country evidence that monetary policy transparency and fiscal credibility reduce the incidence of export price volatility on output volatility. Also, our results indicate that having an explicit fiscal rule and an inflation targeting regime contribute to isolate the economy from terms of trade fluctuations.

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I. INTRODUCTION

Commodity price fluctuations are an important source of volatility in many small open economies. The transmission mechanism of these fluctuations depends to a large extent on the way fiscal and monetary policies are conducted. In effect, in many economies taxes on commodities production and exports are a sizable share of public revenues. When prices of exported commodities increase, the public budget constraint becomes less stringent, providing more space to expand public expenditure. Some countries have tried to isolate their fiscal policies from commodity price cycles by implementing stabilization funds or different types of fiscal rules. The extent to which those funds or rules are able to effectively isolate the economy from commodity prices swings depends on their credibility and transparency. The way monetary policy is conducted and its credibility could also play an important role in the transmission channel of commodity price shocks. The wealth effects that accompanies commodity price booms usually leads to exchange-rate appreciations. Many central banks -- for different reasons-- dislike currency appreciations. If the monetary authority is not credible and transparent, then forward-looking private agents may believe that in response to commodity-price shocks, monetary policy will be more expansive to stabilize the currency. As a result, the sensitivity of the economy to fluctuations in those prices may be increased.

In this paper we analyze, from a general equilibrium perspective and empirically, the role played by fiscal and monetary policy credibility and their transparency in isolating the economy from commodity price fluctuations. We develop a sticky-price small open economy DSGE model, with heterogeneous households and a commodity sector. In the model, monetary and fiscal policies follow systematic rules, but they may not be fully credible: private agents assign a certain probability that in response to shocks either the fiscal authority and/or the monetary authority deviate from the rules. We use the model to analyze the effects of commodity price shocks when these policies lack credibility and are not transparent. We show that under these conditions the effects of a commodity price shock on macro variables are severely magnified: output and consumption expand considerably, inflation rises and monetary policy needs to tighten strongly in response. As a result, investment could be negatively affected in certain cases. We complement these analytical results with some new empirical cross-country evidence on effects of commodity price volatility on output under different degrees of credibility and transparency of macro policies.

The role played by credibility on macro outcomes has received considerable attention since the seminal works of Kydland and Prescott (1977) and Barro and Gordon (1983). In open economy settings, Calvo and Reinhart (2002) argued that lack of credibility in monetary policy is one of the reasons for why developing countries suffer the so called “fear of floating”. The analysis of these and other authors rest on simple macro models. More recently, Erceg and Levin (2003) analyze the effect of lack of credibility on the persistency of inflation in a full blown DSGE model. Our modeling strategy follows precisely the paper by Erceg and Levin. Private agents do not perfectly observe the policy rules followed by the fiscal and monetary authorities. They believe that in response to a commodity price shock, monetary and fiscal policies will deviate from their stated rules. However, monetary and fiscal policies do not actually deviate from the rules. Private agents learn this slowly over time, using a Bayesian approach. Under this Bayesian approach, the signal-to-noise ratio

plays a key role in determining the speed at which agents learn. It turns out that the signal-to-noise ratio is determined by the credibility and the transparency of the policies. The more credible and transparent are the authorities, the faster agents learn the true policies followed by them.

In our analysis we make an effort to distinguish between credibility and transparency. A policy is not credible in our model if the policy instrument –the interest rate or government expenditure—usually deviate by a large amount from the values that are coherent with the systematic behavior of the authority (e.g. when shocks to the respective policy rules are large). Transparency, in turn, refers to the ability of the private sector to observe such deviations. This implies both observing the policy instruments, and also the variables that determine the systematic behavior of the authorities. If the authorities do not disclose their objectives, their procedures, and their assessment of the economic environment, then their policies will not be transparent. On the contrary, if the authority follows well established and clear rules that are communicated to the public, then their policies will be transparent. There is obviously a link between credibility and transparency as suggested by several studies, including Cecchetti and Krause (2002), Geraats et al. (2006), Levin et al. (2004), and Gürkaynak et al. (2006). If policies lack credibility because of their past records, then in order to gain credibility, transparency is necessary.

The importance of credibility and transparency on the effectiveness of macro policies has been emphasized in many papers. When private agents are forward-looking, then the expected future path of policy instruments is crucial for determining current outcomes. Credibility and transparency make it easier for observers anticipating future policy actions by the central bank and the government, thus enhancing the ability of the authorities to anchor expectations.

Given the importance of credibility and transparency, many governments have implemented institutional arrangements to enhance it. In the case of monetary policy, inflation-targeting regimes (IT) are precisely oriented to increase transparency. These regimes define clear objectives for the authority, and its practical implementation has been complemented with clear procedures and a more open communication with the public (through minutes, inflation reports, etc.). In the case of fiscal policy, fiscal rules and fiscal responsibility laws (or transparency laws) have been implemented by a number of countries as a mechanism for improving fiscal discipline and policy outcomes. These arrangements generally enhance fiscal transparency by providing clear statements regarding policy objectives and the manner in which these will be achieved (e.g. Kumar et al., 2009).

In this paper, we present some new evidence on the implication of lack of credibility and lack of transparency for the effectiveness of macroeconomic policy. Credibility and transparency may affect macroeconomic outcomes through different mechanisms. Here, we focus in exploring how both credibility and transparency, determine the way commodity price volatility affects output volatility –as discussed in our analytical model. We perform a series of cross equation regressions between output volatility and export-price (commodity-price) volatility, and interactive terms between export price volatility and different measures of credibility and transparency. Our preliminary results show that monetary policy transparency

and fiscal credibility reduce the incidence of export price volatility on output volatility. Also, our results indicate that having an explicit fiscal rule and an inflation targeting regime contribute to isolate the economy from terms of trade fluctuations.

Our empirical results are in line with the findings of recent research. Most of the recent literature focuses on the case of monetary policy. Blanchard and Riggi (2013) –based on the work by Blanchard and Galí (2009)– find that the lower effects of oil-price shocks on activity and inflation in the last decades is related to a more credible monetary policy. Dincer and Eichengreen (2009) find that more transparency in monetary policy operating procedures are associated with less inflation variability, though not with less inflation persistence. Demertzis and Hughes Hallett (2003), find a negative relationship between inflation variability and central bank transparency. Levin et al. (2004) show that when central banks are more transparent in terms of their objective (e.g. publish numerical targets for inflation), there is less variability in inflation expectations. On the contrary, Gürkaynak, Levin, and Swanson (2005) show that in the U.S.--where there are no explicit targets for inflation--there is a greater tendency for market participants to form inflation expectations based on the recent behavior of inflation. Moreover, Mankiw et al. (2004) find that in the US the dispersion of inflation expectations rises with current inflation, which highlights the lack of an anchor of inflation expectations. In the case of the fiscal policy, Cespedes and Velasco (2011) find that countries with higher institutional quality have had a more countercyclical fiscal policy in response to commodity price booms.

The policy implications of our analysis suggest that the implementation of good macroeconomic policies requires a clear communication of their goals, instruments and decisions to the public. Without institutional arrangements that promote these communication practices the effectiveness of sound macroeconomic policies is substantially impaired, especially to deal with external economic fluctuations such as terms of trade shocks. In contrast, a transparent communication to the public facilitates the building of good reputation of policymakers in their commit to sound macroeconomic policies, anchoring expectations toward the truth intentions of these policies. This anchoring of public expectations helps to mitigate the macroeconomic effects of external shocks.

The rest of the paper is organized as follows. In section 2 we present our theoretical model. Simulation results are described in section 3. Section 4 discusses our empirical evidence. Finally, section 5 concludes.

II. THE MODEL ECONOMY

Our model follows closely Medina and Soto (2007), where we analyze the effect of Chile's structural fiscal rule in isolating the economy from copper price fluctuations. The model structure is a dynamic stochastic general equilibrium (DSGE) model along the lines of Altig et al. (2011). It also follows Galí et al. (2007) to include non-Ricardian households to give a more sensitive role for fiscal policy and it is extended to a small open economy context with commodity exports. In our model economy there are two domestic sectors. One sector produces differentiated goods that are consumed domestically and exported abroad. Another

sector produces a commodity good that is completely exported. Production in this sector requires no input, and a share of revenues is acquired by the government (due to taxes, royalties or state participation in commodity production companies). Firms producing differentiated domestic goods use a constant return technology with two inputs, capital and labor. There are two types of households: Ricardian and non-Ricardian. Consumption of Ricardian's household exhibits habit formation, and there is adjustment cost for investment. Prices and nominal wages are sticky.

A. Households

The domestic economy is inhabited by a continuum of households indexed by $j \in [0,1]$. The expected present value of the utility of household j is given by:

$$U_t(j) = E_t \left\{ \sum_{i=0}^{\infty} \beta^i \left(\ln[C_{t+i}(j) - hH_{t+i}] - \zeta_L \frac{l_{t+i}(j)^{1+\sigma_L}}{1+\sigma_L} + \frac{\zeta_M}{\mu} \left(\frac{M_{t+i}(j)}{P_{C,t+i}} \right)^\mu \right) \right\}, \quad (1)$$

where $l_t(j)$ is labor effort, $C_t(j)$ is a consumption bundle and $M_t(j)$ corresponds to nominal balances held at the beginning of period t by household j . $E_t[\cdot]$ denotes the expectation of the households and firms conditional on the information in period t . Parameter σ_L is the inverse labor supply elasticity with respect to real wages. Preferences display external habit formation, where $H_t = C_{t-1}$ is the aggregate per capita consumption in period $t-1$.

The consumption bundle is a CES aggregator that includes domestically produced goods (home goods) and imported goods (foreign goods):

$$C_t(j) = \left[\gamma_C^{\frac{1}{\eta_C}} C_{H,t}(j)^{\frac{\eta_C-1}{\eta_C}} + (1-\gamma_C)^{\frac{1}{\eta_C}} C_{F,t}(j)^{\frac{\eta_C-1}{\eta_C}} \right]^{\frac{\eta_C}{\eta_C-1}}, \quad (2)$$

where $C_H(j)$ and $C_F(j)$ are the domestic and imported goods consumed by household j , respectively. Parameter η_C is the elasticity of substitution between domestic and foreign consumption goods. For any level of consumption, each household purchases a composite of domestic and imported goods in period t in order to minimize the total cost of its consumption basket.

A.1. Budget constraint and consumption-savings decisions

As in Galí et al. (2007), we assume there are two types of households: Ricardian and non-Ricardian households. Non-Ricardian households have no access to the capital market and, cannot smooth consumption intertemporally. Introducing these types of households is important for analyzing the effects of the fiscal policy. We assume that non-Ricardian households are index in the interval $[0, \lambda]$, where λ corresponds to the share of this type of households in the economy.

Ricardian households

Ricardian households have access to three different types of assets: money $M_t(j)$, one-period non-contingent foreign bonds (denominated in foreign currency) $B_{p,t}^*(j)$, and one-period domestic contingent bonds $d_{t+1}(j)$ which pays out one unit of domestic currency in a particular state. There are no adjustment costs in the portfolio composition. However, each time a domestic household borrows from abroad it must pay a premium over the international price of external bonds. This premium is introduced in the model to obtain a well defined stationary dynamics around its steady state.² Hence, the household budget constraint is given by:

$$P_{C,t}C_t(j) + E_t[q_{t,t+1}d_{t+1}(j)] + \frac{S_t B_{p,t}^*(j)}{(1+i_t^*)\Theta\left(\frac{S_t B_t^*}{P_{Y,t}Y_t}\right)} + M_t(j) =$$

$$W_t(j)l_t(j) + \Pi_t(j) - T_{p,t}(j) + d_t(j) + S_t B_{p,t-1}^*(j) + M_{t-1}(j), \quad (3)$$

where $\Pi_t(j)$ are profits received from domestic firms, $W_t(j)$ is the nominal wage set by household j , $T_{p,t}(j)$ are per capita net taxes, and S_t is the nominal exchange rate. The term $\Theta(\cdot)$ corresponds to the premium domestic households have to pay each time they borrow from abroad which depends on the ratio of net foreign asset position of the country to GDP, where B_t^* is the aggregate net foreign asset position of the economy and $P_{Y,t}Y_t$ is the nominal GDP. Variable $q_{t,t+1}$ is the period t price of domestic contingent bonds normalized by the probability of the occurrence of a particular state.

Ricardian households choose consumption and the composition of their portfolios by maximizing (1) subject to (3). Since we are assuming the existence of a complete set of contingent claims, consumption is equalized across Ricardian households. By aggregating the first order conditions on different contingent claims over all possible states we obtain the following Euler equation:

$$\beta E_t \left[(1+i_t) \frac{P_{C,t}}{P_{C,t+1}} \left(\frac{C_{t+1}(j) - hC_t}{C_t(j) - hC_{t-1}} \right)^{-1} \right] = 1, \quad (4)$$

for $j \in [\lambda, 1]$. Combining (4) with the first order condition with respect to foreign bonds we obtain the following expression for the uncovered interest parity (UIP) condition:

²See Schmitt-Grohé and Uribe (2003) for different ways to get stationary dynamics for small open economy models.

$$\frac{1+i_t}{(1+i_t^*)\Theta\left(\frac{\mathbf{S}_t B_t^*}{P_{Y,t} Y_t}\right)} = E_t\left(\frac{\mathbf{S}_{t+1}}{\mathbf{S}_t}\right) + a_t. \quad (5)$$

The term a_t captures covariance terms and i_t^* is the foreign interest rate.

Non-Ricardian households

As we said, these households have no access to the capital market and own no share in domestic firms. Therefore, they must consume completely their disposable labor income, period by period:

$$P_{C,t} C_t(j) = W_t(j) l_t(j) - T_{P,t}(j). \quad (6)$$

where $j \in [0, \lambda]$.

A.2. Labor supply and wage setting

Each household j is a monopolistic supplier of a differentiated labor service. There is a set of perfect competitive labor service assemblers that hire labor from each household and combine it into an aggregate labor service unit, l_t , that is then used by the intermediate goods producer. The optimal composition of this labor service unit is obtained by minimizing its cost, given the different wages set by different households. In particular, the demand for the labor service provided by household j , $l_t(j)$, is:

$$l_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\varepsilon_L} l_t, \quad (7)$$

where $W_t(j)$ is the wage rate set by household j and ε_L is the elasticity of substitution among differentiated labor services. W_t is an aggregate wage index defined as:

$$W_t = \left(\int_0^1 W_t(j)^{1-\varepsilon_L} dj\right)^{\frac{1}{1-\varepsilon_L}}.$$

Following Erceg *et al.* (2000) we assume that wage setting is subject to a nominal rigidity à la Calvo (1983). In each period, each type of household faces a constant probability $(1-\phi_L)$ of being able to re-optimize its nominal wage. We assume all those households that cannot re-optimize their wages, adjust them according to a weighted average of past inflation and steady-state inflation. Once the wage has been set, households must supply any quantity of labor service that is demanded at that wage.

For simplicity we assume that non-Ricardian households set wages equal to the average wage set by Ricardian households. Given the labor demand for each type of labor, this assumption implies that labor effort of non-Ricardian households coincides with the average labor effort by Ricardian households.

B. Investment and capital goods

Investment goods consist of a CES aggregator of home ($I_{H,t}$) and foreign goods ($I_{F,t}$):

$$I_t = \left[\gamma_I^{\frac{1}{\eta_I}} I_{H,t}^{\frac{\eta_I-1}{\eta_I}} + (1-\gamma_I)^{\frac{1}{\eta_I}} I_{F,t}^{\frac{\eta_I-1}{\eta_I}} \right]^{\eta_I},$$

where η_I is the elasticity of substitution between home and foreign investment goods, and γ_I defines the share of domestic goods in investment. To obtain inertia in the demand for investment goods, we assume that adjusting investment is costly. A representative firm chooses a path for investment that maximizes the present value of its profits:

$$\max_{K_{t+i}, I_{t+i}} E_t \left\{ \sum_{i=0}^{\infty} \Lambda_{t,t+i} \frac{[Z_{t+i} K_{t+i} - P_{I,t+i} I_{t+i}]}{P_{C,t+i}} \right\},$$

subject to

$$K_{t+1} = (1-\delta)K_t + S\left(\frac{I_t}{I_{t-1}}\right)I_t.$$

where K_t is the amount of physical capital available at the begin of period t , δ is the depreciation rate, and Z_t is the rental rate per unit of effective capital. $\Lambda_{t,t+i}$ denotes the stochastic discount factor derived from the intertemporal rate of substitution of consumption for Ricardian households. Function $S(\cdot)$ characterizes the adjustment cost for investment.³

C. Domestic production

This sector consists of two types of firms. One type of firms are producers of differentiated intermediate goods index by $z_H \in [0,1]$. Each of these firms has monopoly power and faces a nominal rigidity that prevents them to adjust optimally prices every period. A second type of

³The adjustment cost of investment satisfies: $S(1) = 1$, $S'(1) = 0$, $S''(1) = -\mu_S < 0$ (see Altig et al., 2005).

firms assembles the differentiated intermediate goods to sell them in the domestic and foreign markets. This last type of firms behaves competitively.

If $Y_{H_{D,t}}$ is the total demand for domestic goods in the local market, and $Y_{H_{F,t}}$ then the domestic and foreign demands for a variety z_H are given by:

$$Y_{H_{D,t}}(z_H) = \left(\frac{P_{H_{D,t}}(z_H)}{P_{H_{D,t}}} \right)^{-\varepsilon_{H_D}} Y_{H_{D,t}}, \quad Y_{H_{F,t}}(z_H) = \left(\frac{P_{H_{F,t}}^*(z_H)}{P_{H_{F,t}}^*} \right)^{-\varepsilon_{H_F}} Y_{H_{F,t}}, \quad (8)$$

where $P_{H_D}(z_H)$ and $P_{H_{F,t}}^*(z_H)$ are the price of variety z_H in the domestic and foreign markets, and P_{H_D} and $P_{H_{F,t}}^*$ are the price indices of $Y_{H_{D,t}}$ and $Y_{H_{F,t}}$.

Production of intermediate varieties of domestic goods is done by firms that act as a monopoly. These firms differentiate their production according to the market in which their variety is being sold. They maximize profits by choosing the price of their variety subject to the corresponding demand and the available technology. Let $Y_{H,t}(z_H) = Y_{H_{D,t}}(z_H) + Y_{H_{F,t}}(z_H)$ be the total quantity produced of a particular variety z_H . The technology available is given by

$$Y_{H,t}(z_H) = A_{H,t} \left[\eta_H \frac{1}{\theta_H} (l_t(z_H))^{\frac{\theta_H-1}{\theta_H}} + (1-\eta_H) \frac{1}{\theta_H} (K_t(z_H))^{\frac{\theta_H-1}{\theta_H}} \right]^{\frac{\theta_H}{\theta_H-1}},$$

where $l_t(z_H)$ is the per capita amount of labor used, $K_t(z_H)$ is the amount of physical capital rented. Variable $A_{H,t}$ represents productivity, which common to all firms in this sector. Parameter θ_H is the elasticity of substitution between labor and capital services and η_H defines the share of labor services in production. Firms determine the optimal mix of inputs by minimizing total cost of production, subject to the constraint imposed by the technology.

Following Calvo (1983) we assume that firms adjust their prices infrequently. In particular, they do so when receiving a signal. In every period the probability of receiving a signal and adjusting their prices in the domestic market is $1-\phi_{H_D}$ for all firms, independently of their history. Similarly, each firm has a probability receiving a signal to be able to re-optimize its exporting price equal to $1-\phi_{H_F}$. The chance of receiving this other signal is equal for all firms, and independent of their history and from the event of adjusting optimally prices in the domestic market. We assume that a firm that does not receive any type of signal updates its prices according to a weighted average of past inflation and steady-state level of inflation.

D. Import goods retailers

We assume local currency price stickiness of imports in order to allow for incomplete exchange rate pass-through in the short-run. To do that, we consider an importing sector where a continuum of firms buy a homogenous good in the foreign market and re-sell it in the domestic market as a differentiated variety.⁴ The demand for a particular variety z_F is given by:

$$Y_{F,t}(z_F) = \left(\frac{P_{F,t}(z_F)}{P_{F,t}} \right)^{-\varepsilon_F} Y_{F,t}, \quad (9)$$

where $P_{F,t}(z_F)$ is the price of variety z_F in the domestic market, and $P_{F,t}$ is the price index of imported goods. Importing firms buy the homogenous foreign good at price $P_{F,t}^*$ in the external market. Each different importer has monopoly power in the domestic market for the specific variety. They adjust their prices infrequently, when receiving a signal. The signal arrives with probability $1 - \phi_F$ each period. As in the case of domestically produced goods, if a firm does not receive a signal, it updates its price according to a weighted average of past inflation and steady-state inflation.

E. Commodity and Foreign sectors

For simplicity, we assume that the commodity sector consist of an endowment that evolves exogenously over time, $Y_{Co,t}$. This endowment is completely exported, and a share of the revenues from sales is owned by the government through taxation or by direct participation in the property of the natural resource.

Foreign agents demand domestic goods and the commodity good. The demand for the commodity good is completely elastic at the price $P_{Co,t}^*$. The law of one price holds for this good. Therefore, the domestic currency price of the commodity is given by,

$$P_{Co,t} = S_t P_{Co,t}^*, \quad (10)$$

We assumed that the log-deviation of the relative price of the commodity follows an AR(1) process,

$$\ln(P_{Co,t}^* / P_t^*) = \rho_{PCo} \ln(P_{Co,t-1}^* / P_{t-1}^*) + (1 - \rho_{PCo}) \ln(\bar{P}_{Co}^*) + \varepsilon_{PCo,t} \quad (11)$$

where $0 < \rho_{PCo} < 1$, $E_{t-1} \varepsilon_{PCo,t} = 0$ and $E_{t-1} (\varepsilon_{PCo,t})^2 = \sigma_{PCo}^2$.

The real exchange rate is defined as the relative price of a foreign price level and the price of a consumption basket in the domestic economy:

⁴This differentiating technology can be interpreted as brand naming.

$$RER_t = \frac{S_t P_t^*}{P_{C,t}}. \quad (12)$$

Foreign demand for domestically produced goods depends on the relative price of this type of goods and the total foreign aggregate demand, C_t^*

$$Y_{H_F,t} = \zeta^* \left(\frac{P_{H_F,t}^*}{P_t^*} \right)^{-\eta^*} C_t^*, \quad (13)$$

where ζ^* corresponds to the share of domestic intermediate goods in the consumption basket of foreign agents, and where η^* is the price elasticity of the demand. This demand can be obtained from a CES utility function with an elasticity of substitution across varieties equal to that parameter.

F. Monetary and Fiscal Policies

F.1. Monetary and fiscal policies under perfect credibility

Monetary policy rule

We assume monetary policy follows a simple rule, where the policy interest rate responds smoothly to deviations of inflation expectation from the inflation target $\bar{\pi}$:

$$\ln\left(\frac{1+i_t}{1+\bar{i}}\right) = \phi_i \ln\left(\frac{1+i_{t-1}}{1+\bar{i}}\right) + (1-\phi_i)\phi_\pi E_t \left[\ln\left(\frac{P_{C,t+1}}{P_{C,t}} \frac{1}{1+\bar{\pi}}\right) \right] + \varepsilon_{MP,t}, \quad (14)$$

Parameter ϕ_i defines the degree of interest rate smoothing and ϕ_π the size of the interest rate response to inflation expectation from deviations from target.

Variable $\varepsilon_{MP,t}$ is an i.i.d. shock to the policy rule with mean 0 and standard deviation σ_{MP}^2 . This shock captures transitory deviations of the policy instrument from values consistent with the policy rule. If σ_{MP}^2 is large, then there are possible large deviations of the interest rate from what would be consistent with the rule. This parameter can be interpreted as the degree of commitment of the monetary authority with the rule. If the monetary authority deviates by a large amount from its policy rule then its credibility will be small. We assume that this parameter is exogenous in the model. However, we may think that if the central bank systematically behaves according to the rule then private agents understand that case σ_{MP}^2 should be small. In the simulations below we consider two cases: one case in which the central bank is not fully committed to the policy rule and lacks reputation (σ_{MP}^2 is large) and another case in which the monetary authority is committed to the policy rule (σ_{MP}^2 is small).

Fiscal policy rule

As a way of characterizing fiscal policy we assume the government follows a fiscal rule similar to the *Structural Balance Fiscal Rule* (SBFR) implemented in Chile since 2001.⁵ The explicit objective of this rule is to smooth the path of public expenditure over the business cycle in order to avoid a pro-cyclical fiscal stance. More precisely, the rule mandates the government to adjust its policy instrument, public expenditure, so as to reach a certain level for the cyclically adjusted or structural balance of the public sector. Here we consider a particular version of this rule, which is based on the Chilean experience, where the structural balance does not only consider cyclical deviations of output from its potential but also takes into account commodity price fluctuations around its long-run level.

Let assume that the target for the structural balance, as a share of GDP, is zero. Then, if τ is the net average income tax rate, \bar{Y}_t is trend or potential GDP and χ is the share of revenues coming from commodity production that are acquired by the government through taxation or by direct participation in the property, then the share of nominal public expenditure over GDP consistent with the rule is given by:

$$\frac{P_{G,t} \tilde{G}_t}{P_{Y,t} Y_t} = \left\{ R_{G,t} + \tau \left(\frac{\bar{Y}_t}{Y_t} \right) + \chi \bar{p}_{Co} \frac{S_t P_t^* Y_{Co,t}}{P_{Y,t} Y_t} \right\}$$

where $R_{G,t} = \left(1 - (1 + i_{t-1}^*)^{-1} \Theta_{t-1}^{-1}\right) S_t B_{t-1}^* / P_{Y,t} Y_t$ corresponds to the debt service as a share of GDP. We allow for deviation of actual public expenditure from the level that is fully consistent with the rule. Specifically, public expenditure in each moment will be given by

$$\frac{P_{G,t} G_t}{P_{Y,t} Y_t} = \frac{P_{G,t} \tilde{G}_t}{P_{Y,t} Y_t} \exp(\varepsilon_{G,t}) \quad (15)$$

where $\varepsilon_{G,t}$ is an *i.i.d.* shock with mean zero and variance σ_G^2 . As in the case of the monetary policy, the size of this shock is a measure of the commitment of the fiscal authority with the rule, and defines its degree of reputation or credibility.

How relevant is this type of rule for characterizing the behavior of countries? While it is true that not many countries follow explicitly this type of rules, a large number of them declares to be following an explicit fiscal-rule. According to Kumar et al. (2009), by 2009 at least eighty countries had in place a national or a supranational fiscal-rule. Furthermore, in many countries that have not explicitly established a particular behavioral rule, their fiscal policy follow implicitly a rather systematic behavior. In the case of commodity exporting countries,

⁵ The description of the structural balanced fiscal rule is an adaptation of the description of the rule in Marcel et al. (2001).

many of them have established wealth or stabilization funds where windfalls from commodity booms are saved. The rule described above resembles in some dimensions the way these stabilization funds work. Finally, measures of structural balances that adjust by commodity price movements are becoming increasingly important to assess the fiscal position of countries (see e.g. Bornhorst et al., 2011). Thus, although a country might not have a target for the structural balance, policymakers could use it as a benchmark to conduct its fiscal policy.

F.2. Imperfect credibility and lack of transparency

Under imperfect credibility, the private sector believes that in response to a commodity price shock either the monetary and/or the fiscal authorities may persistently deviate from their respective policy rules. In the case of monetary policy, the private sector believes that the central bank will take a more expansive monetary stance in response to an increase in the price of the commodity as a way of avoiding a large appreciation of the currency.⁶ Thus, the perceived monetary policy rule under imperfect credibility is given by:

$$\ln\left(\frac{1+i_t}{1+\bar{i}}\right) = \varphi_i \ln\left(\frac{1+i_{t-1}}{1+\bar{i}}\right) + (1-\varphi_i)\varphi_\pi \left(E_t \left[\ln\left(\frac{P_{C,t+1}}{P_{C,t}} \frac{1}{1+\pi}\right) \right] - \varpi_\pi \ln\left(\frac{P_{Co,t}^*}{P_t^*}\right) \right) + \varepsilon_{MP,t}, \quad (16)$$

where ϖ_π captures the way the monetary policy will respond to a commodity price shock according to the beliefs of the private sector. Similarly, in the case of fiscal policy, the private sector believes that, after a commodity price shock, public expenditure will respond by more than what would be prescribed by the rule (15). In practice, when there is an increase in the commodity price, public revenues also rise. Then, due to different considerations, the authority may be tempted to expand its expenditure beyond the rule. Thus, under imperfect credibility, the private sector believes that public expenditure will be given by:

$$\frac{P_{G,t}G_t}{P_{Y,t}Y_t} = \left\{ R_{G,t} + \tau \left(\frac{\bar{Y}_t}{Y_t} \right) + \chi \left(\bar{P}_{Co} + \varpi_G \left(\frac{P_{Co,t}^*}{P_t^*} \right) \right) \frac{S_t P_t^* Y_{Co,t}}{P_{Y,t} Y_t} \right\} \exp(\varepsilon_{G,t}) \quad (17)$$

where ϖ_G determines the perceived degree of pro-cyclicality of fiscal policy in response to commodity price fluctuations.

In our simulations we consider the cases where monetary and fiscal authorities actually behave according to their rules (14) and (15), but the private sector believes that with certain probabilities the rules are in fact (16) and (17). Notice that the possibility of non-persistent

⁶ A large amount of literature documents the existence of *fear of floating*, in particular, in emerging markets (Calvo and Reinhart, 2002). A recent paper by Aizenman, Hutchison and Noy (2011) show that central banks in emerging markets that follow an inflation targeting regime tend to adjust their policy rate to exchange rate fluctuations (after controlling for inflation and inflation expectations). Moreover, the response is more significant in the cases where commodities represent a large share of exports.

deviations from the rules given by the shocks $\varepsilon_{MP,t}$ and $\varepsilon_{G,t}$ makes it non feasible for the private sector to infer the actual macro rules just by observing the behavior of the policy instruments and the other macro variables that enter in equations (14) and (15). It will be through a learning process discussed below that the private sector will eventually realize that macroeconomic policy instruments have not deviated from rules (14) and (15).

Together with analyzing credibility problems we also consider the implications of lack of transparency. Let's assume that due to measurement errors in some variables (e.g. GDP, inflation expectations or potential output), the private sector observes the deviations of the policy instruments with an error.⁷ In particular, for the case of monetary policy, the observed deviation of the interest rate from the rule is given by,

$$dev_{MP,t} = (i_t - \varphi_i i_{t-1} - (1 - \varphi_i) \varphi_\pi E_t \pi_{t+1}) + e_{1,t} \quad (18)$$

where $e_{1,t}$ corresponds to the measurement error for the monetary policy rule. In the case of fiscal policy, the observed deviation of public expenditure from the rule is given by:

$$dev_{G,t} = \left(\frac{P_{G,t} G_t}{P_{Y,t} Y_t} - \frac{P_{G,t} \tilde{G}_t}{P_{Y,t} Y_t} \right) \exp(e_{2,t}) \quad (19)$$

where $e_{2,t}$ is the measurement error in the observation of the fiscal rule. Measurement errors $e_{1,t}$ and $e_{2,t}$ have zero mean and standard deviations σ_1^2 and σ_2^2 . These variances define the degree of the transparency of the monetary and fiscal policies. For instance, if σ_1^2 is small we say that monetary policy is transparent. Also, if σ_2^2 is small then fiscal policy is transparent.

Given the fact that both policies may deviate from the respective rules and the measurement errors in those deviations, the private sector needs to infer the actual and future behavior of the authorities. They considers four possible cases: **(1)** policies follow rules (14) and (15); **(2)** the fiscal rule follows (15) and monetary policy behaves according to (16); **(3)** the monetary policy rule reacts according (14) and the fiscal rule follows (17); and **(4)** monetary and fiscal policies follow (16) and (17). The first case is when both policies are credible. The second case is when fiscal policy is credible but monetary policy is not. The third case is when monetary policy is credible but fiscal policy is not. Finally, the fourth case is when both policies are not credible. Private agents assign a probability to each of those cases. We denote by $pr_{i,t}$ the probability at time t of case $i = 1, 2, 3$, and 4.

⁷ Transparency can be interpreted in different ways. Here, lack of transparency is related to inability of private agents of perfectly observe policy actions. In general, transparency can change with the movement in the policy instruments. In our framework, we abstract from that and from a more strategically behavior of authorities when they choose their reactions in the case of imperfect credibility.

Equations (18) and (19) provide noise signals about the systematic behavior of monetary and fiscal policies. We assume that the private agents makes a Bayesian inference to update their beliefs about the probabilities $pr_{i,t}$ and the discretionary components of the polices, $\varepsilon_{MP,t}$ and $\varepsilon_{G,t}$. To implement this Bayesian approach we define the following vector of states:

$$\xi_t = \begin{bmatrix} pr_{1,t} & pr_{2,t} & pr_{3,t} & pr_{4,t} & \varepsilon_{MP,t} & \varepsilon_{G,t} \end{bmatrix}'$$

Upon observing $dev_{MP,t}$ and $dev_{G,t}$, the private sector makes an inference about ξ_t using the Kalman Filter:

$$\xi_{t|t} = \begin{bmatrix} pr_{1,t|t} & pr_{2,t|t} & pr_{3,t|t} & pr_{4,t|t} & \varepsilon_{MP,t|t} & \varepsilon_{G,t|t} \end{bmatrix}'$$

where $pr_{i,t|t}$ is the probability assigned of being in case $i = 1, 2, 3$, or 4 in time t , based on information available up to time t . Similarly, $\varepsilon_{MP,t|t}$ and $\varepsilon_{G,t|t}$ are the magnitude of macroeconomic policies shocks inferred by the private agents based on the information until t . This inference based on the Kalman filter provides the optimal inference about the unobservable states based on the available information (see appendix for a detailed description on how this is implemented).

III. CALIBRATION AND SIMULATIONS

To solve the model we approximate the dynamic equations around its steady-state with log-linear expansions. Then we solve the log-linear decision rules from the behavioral equations. The parameter values for the numerical solution are summarized in Table 1.

The ratio of total exports to GDP is calibrated to 33 percent, commodity production to 10 percent of GDP, and fiscal commodity revenues to 4 percent of GDP. Government spending is calibrated to 12 percent and is assumed to be completely biased towards domestically produced goods. The intertemporal elasticity of substitution is fixed in 1.0. Also, we consider a unitary labor supply elasticity, which is somehow lower than traditional value used in U.S. real business cycle models. The elasticity of substitution between domestic and imported goods is also set to 1.0. The shares of domestic produced goods in consumption and investment are 65 and 50 percent, respectively. Monetary policy rule has a smoothing coefficient of 0.75 and a feedback coefficient to inflation equal to 1.5.

In the simulations below we consider a positive commodity price shock of 25% with a high degree of persistency: $\rho_{PCo} = 0.95$. As mentioned above, the monetary and fiscal authorities strictly follow the rules (14) and (15). In the cases where there is imperfect credibility, we assume that private agents believe that the monetary policy rule incorporates a coefficient $\varpi_\pi = 0.005$ in equation (16). That is, there is a small feedback from the commodity price to the interest rate. In the case of the fiscal rule, under imperfect credibility private agents believe that the rule has a feedback coefficient of the commodity price into government

expenditure of $\varpi_G = 0.5$. Finally, the prior probabilities that in period 0 either or both authorities deviate from their stated rules (14) and (15) are $pr_{i,00} = 0.25$, for $i = 2,3,4$.

A. Imperfect Credibility on the Monetary and Fiscal Rules

We simulate the effects of a commodity price shock comparing the responses when both rules are credible and transparent, with the ones obtained under imperfect credibility and lack of transparency (cases (iv) describe above). For this last case we assume that $\sigma_{MP} = 0.05\%$, $\sigma_G = 0.10\%$, $\sigma_1 = 2\%$ and $\sigma_2 = 2\%$.

When policies are credible and there is full transparency, the commodity price shock generates a small expansion in output and almost no change in inflation, with a moderate appreciation of the currency (figure 2). Given the fiscal rule, public expenditure slightly responds to the commodity price increase, and public savings rises. Ricardian households perceive an increase in their wealth (future reduction in taxes), and expand their consumption. However, this effect is small and their consumption does not increase much. Non-Ricardian households, as their disposable income does not change (employment and real wages remain almost constant), do not increase their consumption. As a consequence, aggregate consumption barely moves on impact, after the commodity price increase, and slowly increases afterward. Firms, in turn, increment their investment because future increases in consumption rise the demand for their products, and the appreciation of the currency makes investment cheaper. Since inflation remains almost constant, there is no monetary policy response. The current account improves despite of the increase in investment and the decrease in private savings thanks to the rise in public saving. Hence, when policies are designed to be counter-cyclical or a-cyclical, and are transparent and credible, the economy becomes isolated from commodity price shocks.⁸

Under imperfect credibility and lack of transparency, firms and households assign a prior probability of 25% that the monetary and fiscal authorities are deviating from their respective rules. Lack of transparency makes it hard to private agents update their prior beliefs regarding these deviations. Thus, they keep assuming for a extended period that macroeconomic policies deviate from their respective rules. In other words, private agents believe that the government is saving less than what it is actually doing, and that monetary policy is less contractive than its actual policy stance (figure 1).

Under these circumstances, the commodity price shock generates a much larger increase output and demand when compared to the case of full credibility, and inflation rises substantially (figure 2). Households expand their consumption today and in the future. Under

⁸ In Medina and Soto (2007), we show that if macro policies are not counter or a-cyclical (e.g. if fiscal policy keeps a balanced budget or the monetary policy tries to stabilize the exchange rate) in response to a commodity price increase, then the effect in output, inflation, and aggregate demand of that shock would be severely magnified.

imperfect credibility households believe that public expenditure will increase in a persistent way in the future, with the consequent expansion in demand, production, and labor income. They also perceive a loose monetary stance, which reinforces the increase in current and expected consumption. The perceived increase in public expenditure and private consumption, and the loose monetary policy lead to an increase in investment. Labor demand rises and current and expected marginal cost increase. As a result there is a substantive increase in inflation. Given the monetary policy rule, and the fact that the monetary authority is fulfilling it, the interest rate rises aggressively and in a persistent way so as to bring inflation back to target.

Notice that the real exchange rate depreciates on impact despite the monetary policy contraction. This is because the real interest rate falls initially due to the increase in expected inflation. Only after some periods, the monetary authority increases the interest rate by enough so as to raise the real interest, and to contract demand. It is just then that the real exchange rate appreciates. Since the government follows its fiscal rule, there is an increase in the primary fiscal balance similar to the one obtained under full credibility. However, the depreciation of the currency enhances the domestic-currency value of the structural public income coming from the commodity sector. Then, public expenditure rises by more than what it does when credibility is imperfect. Finally, the larger increase in investment, and the smaller savings occurring under imperfect credibility lead to a smaller increase in the current account.

B. The role of monetary policy transparency

Next, we consider the case where monetary policy, despite lacking credibility, is fully transparent. More precisely, the public is able to observe more clearly any deviation of the interest rate from what would be its value according to the systematic behavior of the central bank. For this case we assume that $\sigma_1 = 0\%$. Under this situation, despite the prior belief that the central bank would have a more loose monetary policy in response to the commodity price shock, private agents learn faster that the monetary authority is not deviating from its rule. This is reflected in the probabilities that private agents assign to cases 2 and 4, which converge quickly toward zero (figure 3).

When the monetary policy is more transparent, output and inflation still rise by more than what they do under full credibility. However, now these increases are more muted than in the case where monetary policy is non-credible and lacks transparency. Initially, aggregate consumption expands by more than under perfect credibility, but less than the case where monetary policy is not transparent. A similar pattern is observed in investment. Employment also tends to converge fast towards the path it would follow under perfect credibility. On impact, the real exchange rate depreciation is smaller than in the case of lack of credibility and transparency, but the subsequent appreciation is more intense and persistent. This reflects the fact that now private agents understand faster that monetary policy will be tighter in the future. The appreciation of the currency and the more muted and less persistent response in activity leads also to a more muted and less persistence hike in inflation. These variables converge back to its target faster than in the previous case. Notice that the interest rate rises

by less, and also in a less persistent way, than under lack of credibility and transparency. This reflects the fact that monetary policy is more effective (figure 4).

C. Credible and transparent monetary policy

Consider now the case of a central bank that enjoys credibility. That is, a central bank that usually does not deviate from its policy rule. As before, we assume that private agents believe that, with a certain probability, the monetary authority will deviate from historical rule and will implement systematically a more expansive policy in response to a commodity price shock. However, private agents also understand that the central bank does not deviate in a random way from any systematic behavior. More precisely, we assume that $\sigma_1 = \sigma_{MP} = 0\%$. Since private agents observe with full transparency that the central bank has not deviated from its previous policy rule, and since they understand that this cannot be the results of a random shock to the rule, then they learn immediately that monetary policy is following the behavior dictated by the rule in (15) (figure 5).

By affecting expectations, monetary policy becomes very effective in controlling inflation. In fact, inflation remains virtually stable after the shock. Output and employment still expand strongly after the shock because of the lack of credibility in fiscal policy. However, now they converge quickly to the path that would prevail under perfect credibility in both policies. The increase in consumption is smaller than the previous case, but still significantly above what would occur if both policies were perfectly credible. This is due in part to the behavior of non-Ricardian households, whose labor income rises in response to the shock. In contrast, investment rises by less than in the previous case and even falls short from the path it would follow under perfect credibility.

Now monetary policy needs to counteract the perceived expansion in public expenditure. Since investment is more sensitive to the interest rate than consumption, its response to the shock is more contained. The increase in the interest rate that follows the shock is the result from inflationary pressures coming from the expansion in output. Notice that in this case there is a real exchange rate appreciation that is even larger than in the case of perfect credibility. This occurs because the monetary policy response to the shock is stronger than what would be under full credibility in the two policies. In summary, lack of credibility regarding fiscal policy requires a monetary policy that changes the composition of aggregate demand, with more consumption and less investment. This policy manages to stabilize inflation at the cost of generating a larger appreciation of the currency (figure 6).

D. Credible and transparent monetary policy and transparent fiscal policy

Finally, we consider the case where monetary policy is fully credible and transparent, and where fiscal policy is also fully transparent but lacks credibility. In particular, we consider $\sigma_1 = \sigma_{MP} = \sigma_2 = 0$.

In this case, private agents extract better information from the fiscal policy. Therefore, they learn fast that fiscal policy has not deviated from the structural balance rule, described above. Since private agents learn faster that neither fiscal policy nor monetary policy is deviating from their actual rules, the responses of macroeconomic variables are virtually the same as the ones under perfect credibility. There are only short-run differences associated to the fact that right on impact private agents assume that with a certain probability fiscal policy will deviate. But this is only in the short run because of the learning process. As a result, monetary policy is able to stabilize inflation with a small appreciation of the currency. The more muted responses of output and aggregate demand do not need a lower investment as in the case without fiscal transparency. Thus, when monetary policy is credible and fiscal policy is not, a transparency in the fiscal decisions implies a better isolation from commodity price shocks and closer to a situation of perfect credibility.

IV. EMPIRICAL EVIDENCE

In this section we present some empirical evidence on the implication of lack of credibility and transparency for the transmission of commodity price shocks. We focus on the impact on activity, measured by the standard deviation of GDP growth. Following the discussion in the previous section, our hypothesis is that lack of credibility and transparency will amplify the effects of commodity price shocks on domestic activity. Thus, according to this hypothesis, the relation between the volatility of GDP and the volatility of exported commodity price would be increased if policies are not credible and transparent. To test for this, we ran a series of cross-section regressions of the type:

$$\sigma_{\Delta Y,i} = \alpha_0 + \alpha_1 \sigma_{\Delta P_x,i} + \alpha_2 q_i \sigma_{\Delta P_x,i} + \varepsilon_i \quad (20)$$

where $\sigma_{\Delta Y,i}$ is the volatility of activity in country i , $\sigma_{\Delta P_x,i}$ is the volatility of the exported commodity price of the country, and q_i is a variable that measures credibility and/or transparency of policies.

To measure the volatility of exported commodity prices we consider alternative cases. First, we use as a proxy, the standard deviation of export deflator growth. This measure does not necessarily reflect the incidence of commodity-price shocks, as many countries are not commodity exporters. Therefore, as a second proxy, we consider the standard deviation of a commodity price index constructed by Cespedes and Velasco (2011) – CV index, thereafter. These authors identify the two main commodity exports for a large set of countries. Then, they construct a commodity price index for each country by weighting the prices of these two main commodity exports according to their share in total exports. Unfortunately, despite of the large set of countries covered by Cespedes and Velasco, the inclusion of the CV index in our regressions considerably reduces the size of the sample. Therefore, as a third measure, we utilize the standard deviation of the export deflator growth for each country interacting with the share of commodity goods in total exports.

Measuring the transparency and credibility of monetary and fiscal policies is not straight forward. For example, there are different dimension of transparency for each policy, some of which may be more relevant than others for the sensitivity of the economy to external shocks. In our model, transparency is related to the extent to which the private sector is able to observe the evolution of policy instruments, the systematic behavior of the authorities (their rules) and the variables that affect this systematic behavior.

In the case of monetary policy, there have been many efforts in the literature to construct measures of transparency. Most of these studies focus on particular aspects of transparency. In this paper we use the index developed by Eijffinger and Geraats (2006) and later extended and updated by Dincer and Eichengreen (2007 and 2009) –the EG-DE index thereafter– where transparency is measured taking into account multiple dimensions of it. More precisely, different sub-indices are constructed to capture aspects related to openness about policy objectives, about data, models and forecasts, about the way decisions are taken, about the policy implications of those decisions, and openness about their implementation (see Dincer and Eichengreen, 2009 for more details). Some of these dimensions are more related than others to the concept of transparency embedded in our simulations. However, we think that the whole index is a good proxy for the concept of monetary policy transparency that we have in mind.

In the case of fiscal transparency, there are fewer studies trying to quantify it. One of the few attempts is by Hameed (2005) which draws from the *Code of Good Practices on Fiscal Transparency* approved by the IMF Board in 1998. Another index, which is the one used in this paper, is the Open Budget Index (OBI) constructed by the International Budget Partnership (<http://internationalbudget.org/>) based on a detailed survey submitted to their affiliated countries. The index assigns a score to each country based on the information they make available to the public throughout the budget process. Surveys have been conducted every two years since 2006. The last survey, from 2010, covers more than 90 countries.

Figure 9 presents the correlation between the volatility of GDP growth for the period 1995-2010 and the average EG-DE monetary transparency index for the period 1998-2006, and the OBI fiscal transparency index of 2006. Both transparency indices are increasing in the degree of transparency: the larger the values of the index, the more transparent are the policies. There is a clear negative correlation between growth volatility and monetary policy transparency. However, the correlation between fiscal transparency and output volatility is less clear.

Measuring the credibility of policies is also a difficult task. One way of measuring credibility is to quantify the deviation of economic outcomes from policy targets. For example, in the case of countries that follow an Inflation Targeting regime (IT), a measure of credibility would be the degree of discrepancy of inflation from target. One problem with this measure is that inflation may deviate from target for shocks that are beyond the control of monetary authority. If the public understands this, then deviations of inflation from target would not necessarily jeopardize the credibility of the monetary policy. For this reason, some papers utilize as a measure of credibility the discrepancy of expected inflation --rather than actual inflation-- from target. Unfortunately, this measure of credibility would only be available for

IT countries. In the case of fiscal policy, computing deviation from policy objectives is more cumbersome because different governments may have targets for different fiscal variables (e.g., primary surplus, expenditure growth, structural balance, etc.)

In our model, credibility depends on the size of the shocks to the monetary policy rule and to the fiscal rule. In other words, credibility depends on the size of the deviation of policy instruments from the level they should have according to the systematic behavior of the authority. Therefore, as a first approach to measure monetary policy credibility we ran time series regressions for each country to model the systematic behavior of the monetary authority. Then, we computed the standard deviations of the residuals of those regressions as our proxy for monetary policy credibility. The larger the standard deviation of the residual, less credible is the policy. In the case of fiscal policy credibility, we use as a proxy, the standard deviation of the structural balance of each country which is precisely the parameter that governs fiscal credibility in our model. Since we are interested in the amplifying effects of lack of credibility rather than the direct implication of policy volatility on output, our measures of credibility are computed using data for the period 1985-2000, prior to the period considered for computing the volatility of GDP utilized as the dependent variable in the regressions.⁹

The results of the regressions are reported in table 1. The first set of columns of the table reports the results obtained when the dependent variable is computed using the period 1995-2010 and we use the standard deviation of export deflator (specifications (1)—(6)). The last set of columns of the table 1 reports the results obtained when the volatility of GDP growth is computed with the period 1998-2008 and we use the standard deviation of the CV commodity price index (specifications (7)—(11)).¹⁰ The signs of the regressions reported in table 1 are in general coherent with our priors. Export price volatility increases GDP growth volatility, although this result is statistically significant only when we consider the export deflator and it is not when we use the CV commodity price index. The volatility of the commodity price index is not statistically significant in the regression. As mentioned above, when this variable is utilized the sample size falls dramatically.

When export price volatility interacts with our measures of transparency and credibility we find that monetary transparency is statistically significant in reducing the impact of export price volatility on output volatility (specification (1)). We also find that, the lower the fiscal credibility the larger is the effect of export price volatility on output (specification (4)). When export price volatility interacts with monetary credibility and fiscal transparency, the coefficients present the wrong sign and are not statistically significant (specifications (2) and (3)). Similar results are obtained when the volatility of the exported commodity price (CV index) is interacted with our measures of transparency and credibility. Monetary transparency

⁹ There are three years of overlapping observations. Ideally, we would like to use non-overlapping data. Unfortunately, that would imply to considerably reduce the sample in one or the other estimation. We considered alternative scenarios with fewer overlapping data and the results are virtually the same.

¹⁰ We considered the simple 1998-2008 because it minimizes the impact of two major crisis affecting emerging markets: The Asian crisis of 1997-98 and the global recession of 2008-2009

and fiscal credibility seems to be relevant for reducing the impact the effects of commodity price volatility on output volatility (specifications (7) and (10)). However, in this case there is a counterintuitive result: less monetary policy credibility also contributes to dampen the impact of commodity price exports (specifications (8)).

Together with our measures of transparency and credibility, we also consider dummy variables to control for whether the country has an Inflation Targeting regime or whether fiscal policy is conducted explicitly through a rule. Both types of regime could, in principle, introduce more transparency in the conduction of macro policies. Therefore, they could be thought as alternatives to our measures of transparency. The results show that both types of policies reduce the impact of export price and commodity price volatility on output volatility (specifications (5), (6) and (11); the fiscal rule dummy cannot be used with the CV index due to lack of data).

For countries where commodities are not a relevant share of their exports, the export deflator would not be a good proxy of the incidence of commodity price volatility on output volatility. Therefore, as a robustness check, we run the same regression as before but interacting the volatility of the export deflator with the share of primary exports in GDP (see table 2). In general, the results do not change: export price volatility increases the volatility output –although this result is not always statistically significant. Also, we find that monetary transparency, fiscal policy credibility, and IT regimes reduce the impact of export price volatility on output.

V. CONCLUSIONS

Isolating a commodity rich economy from terms-of-trade movements requires a monetary regime with exchange rate flexibility. At the same time, a fiscal policy that isolates public spending from fluctuations in revenues stemming from commodity price shocks is needed. Implementation of monetary and fiscal rules that induce these types of systematic behavior is a necessary condition to protect the economy against commodity price shocks. However, as we show with our analytical model, the mechanic implementation of these rules is not enough to deal with commodity prices fluctuations. In particular, these rules can be less effective when monetary and fiscal authorities lack credibility and transparency. Empirically, we also present evidence that the degree of transparency and credibility of policies tend to reduce the incidence of export price volatility on output volatility.

Hence, institutional arrangements designed to communicate clearly the public the goals, instruments and decisions of policies can help to mitigate the macroeconomic effect of terms of trade fluctuations because these arrangements enhance the transparency of policies. Also, a good reputation of policymakers to commit to these types of rules increases the effectiveness of macro policies. Both transparency and reputation, improve the credibility of countercyclical or a-cyclical macro policies, by anchoring expectations in line with the stated goals of policymakers.

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Table 1. Baseline Parameterization

	Value	Description
Household Preferences		
β	0.9975	Subjective discount factor
μ	0.2	Money demand elasticity to $i/(1+i)$
σ_c	1.0	Elasticity of intertemporal substitution in consumption
σ_l	1.0	Inverse of the labor supply elasticity
h	0.75	Habit formation coefficient
λ	0.7	Fraction of Non-Ricardian Households
Consumption, Government Expenditure and Investment Baskets		
γ_c	0.65	Share of domestic goods in consumption
η_c	1.0	Elasticity of substitution in consumption between domestic and imported goods
γ_I	0.5	Share of domestic goods in investment
η_I	0.5	Elasticity of substitution in investment between domestic and imported goods
γ_G	1.0	Share of domestic goods in gov't expenditure
Capital Accumulation		
μ_s	2.0	Investment adjustment cost coefficient
δ	6%	Depreciation rate (annual)
Nominal Rigidities		
ϕ_L	0.75	Prob adjusting wages
ξ_L	0.5	Wage indexation
ϕ_{H_D}	0.75	Prob adjusting P_{H_D}
ξ_{H_D}	0.5	Domestic goods indexation (home)
ϕ_{H_F}	0.75	Prob adjusting P_{H_F}
ξ_{H_F}	0.5	Domestic goods indexation (abroad)
ϕ_F	0.75	Prob adjusting P_F
ξ_F	0.5	Imported goods indexation
Domestic Production Technology		
η_H	0.66	Labor share in domestic production
θ_H	1.0	Elasticity of substitution between labor and capital

Table 1. (cont.)

	Value	Description
Foreign Sector		
NX/Y	1%	Net exports to GDP ratio
η^*	1.0	Price elasticity of foreign demand for domestically
ρ		Elasticity of the external supply of debt
Y_{Cd}/Y	10%	Commodity exported share in total GDP
Monetary Policy		
ϕ_i	0.75	Interest rate smoothing
ϕ_π	1.5	Reaction to inflation
Fiscal Sector		
G/Y	12%	Government expenditure to GDP ratio
χ	40%	Share of commodity exports sector holds for the
τ	7.5%	Average net tax rate

APPENDIX A: SIMULATION UNDER IMPERFECT CREDIBILITY

First, the dynamic responses to monetary and fiscal policy shocks ($\varepsilon_{MP,t}$ and $\varepsilon_{G,t}$) can be described by:

$$\hat{X}_t = P\hat{X}_{t-1} + Q_{MP}\varepsilon_{MP,t}, \varepsilon_{MP,t} \sim N(0, \sigma_{MP}^2) \quad (\text{A.1})$$

$$\hat{X}_t = P\hat{X}_{t-1} + Q_G\varepsilon_{G,t}, \varepsilon_{G,t} \sim N(0, \sigma_G^2) \quad (\text{A.2})$$

where \hat{X}_t is a vector containing all endogenous variables of the model (expressed as log deviation from their balanced growth paths) and $\varepsilon_{MP,t}$ and $\varepsilon_{G,t}$ are the monetary and fiscal shocks. P , Q_{MP} and Q_G are a matrix and two vectors, respectively, which are functions of the structural parameters.

Second, conditional of being in each of the four cases of macro policies, the responses of the economy to a commodity price shock ($\hat{p}_{Co,t}^*$) is given by:

$$\hat{X}_t = P\hat{X}_{t-1} + Q_{Co,i}\hat{p}_{Co,t}^*, \hat{p}_{Co,t}^* = \rho_{PCo}\hat{p}_{Co,t-1}^* + \varepsilon_{PCo,t}, \varepsilon_{PCo,t} \sim N(0, \sigma_{PCo}^2) \quad (\text{A.3})$$

where $Q_{Co,i}$ is vector that corresponds to the responses under the case i .

Under perfect credibility, the dynamic response of the model economy to commodity price shocks is characterized by (A.3) for the case $i = 1$.

Under imperfect credibility, the private sector will use its inference about the four cases and the size of monetary and fiscal shocks to obtain the dynamic response to a commodity price shock:

$$\hat{X}_t = P\hat{X}_{t-1} + (Q_{Co,1}pr_{1,t|t} + Q_{Co,2}pr_{2,t|t} + Q_{Co,3}pr_{3,t|t} + Q_{Co,4}pr_{4,t|t})\hat{p}_{Co,t}^* + Q_{MP}\varepsilon_{MP,t|t} + Q_G\varepsilon_{G,t|t}$$

where $pr_{i,t|t}$ ($i=1,2,3,4$), $\varepsilon_{MP,t|t}$, and $\varepsilon_{G,t|t}$ are the Bayesian inference using the information until t . This inference is updated with the Kalman Filter:

$$\begin{bmatrix} \hat{p}_{Co,t}^* pr_{1,t|t} \\ \hat{p}_{Co,t}^* pr_{2,t|t} \\ \hat{p}_{Co,t}^* pr_{3,t|t} \\ \hat{p}_{Co,t}^* pr_{4,t|t} \\ \varepsilon_{MP,t|t} \\ \varepsilon_{G,t|t} \end{bmatrix} = \begin{bmatrix} \rho_{PCo}\hat{p}_{Co,t-1}^* pr_{1,t-1|t-1} \\ \rho_{PCo}\hat{p}_{Co,t-1}^* pr_{2,t-1|t-1} \\ \rho_{PCo}\hat{p}_{Co,t-1}^* pr_{3,t-1|t-1} \\ \rho_{PCo}\hat{p}_{Co,t-1}^* pr_{4,t-1|t-1} \\ 0 \\ 0 \end{bmatrix} + K \begin{bmatrix} \hat{p}_{Co,t}^* - (pr_{1,t-1|t-1} + pr_{2,t-1|t-1} + pr_{3,t-1|t-1} + pr_{4,t-1|t-1})\rho_{PCo}\hat{p}_{Co,t-1}^* \\ dev_{MP,t} + (1 - \varphi_i)\varphi_\pi\varpi_\pi(pr_{2,t-1|t-1} + pr_{4,t-1|t-1})\rho_{PCo}\hat{p}_{Co,t-1}^* \\ dev_{G,t} - (pr_{3,t-1|t-1} + pr_{4,t-1|t-1})\varpi_G\chi\frac{Y_{Co}}{Y}\rho_{PCo}\hat{p}_{Co,t-1}^* \end{bmatrix}$$

where K is the Kalman gain matrix. When the monetary and fiscal policies follow rules (14) and (15) under imperfect credibility, $dev_{MP,t} = dev_{G,t} = 0$ for all t . However, the reputation and transparency problems prevent an immediate inference of $pr_{1,t|t} = 1$ and $pr_{2,t|t} = pr_{3,t|t} = pr_{4,t|t} = \varepsilon_{MP,t|t} = \varepsilon_{G,t|t} = 0$ by the private sector. In contrast, the private sector will learn slowly about this situation.

To obtain the Kalman gain matrix, K , we proceed as follows. Lets define the matrices F_ξ , Q_ξ , H_ξ and R_e as

$$F_{\xi} = \begin{bmatrix} \rho_{PCo} & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho_{PCo} & 0 & 0 & 0 & 0 \\ 0 & 0 & \rho_{PCo} & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho_{PCo} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}, Q_{\xi} = \begin{bmatrix} pr_{1,0|0}\sigma_{PCo}^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & pr_{2,0|0}\sigma_{PCo}^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & pr_{3,0|0}\sigma_{PCo}^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & pr_{4,0|0}\sigma_{PCo}^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sigma_{MP}^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma_G^2 \end{bmatrix},$$

$$H_{\xi} = \begin{bmatrix} 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & -\varpi_{\pi}(1-\varphi_i)\varphi_{\pi} & 0 & -\varpi_{\pi}(1-\varphi_i)\varphi_{\pi} & 1 & 0 \\ 0 & 0 & \varpi_{\pi} \frac{Y_{Co}}{Y} \chi & \varpi_{\pi} \frac{Y_{Co}}{Y} \chi & 0 & 1 \end{bmatrix}, R_e = \begin{bmatrix} 0 & 0 & 0 \\ 0 & \sigma_1^2 & 0 \\ 0 & 0 & \sigma_2^2 \end{bmatrix}$$

where $pr_{i,0|0}$ is the prior probabilities of being in case i . Thus, K can be obtained as the limiting value of the following iterative process:

1. Ω_0 solves $\Omega_0 = F_{\xi}\Omega_0F_{\xi}' + Q_{\xi}$
2. $K_t = \Omega_{t-1}H_{\xi} [H_{\xi}'\Omega_{t-1}H_{\xi} + R_e]^{-1}, \Omega_t = F_{\xi}(I - K_tH_{\xi}')\Omega_{t-1}(I - H_{\xi}K_t')F_{\xi}' + F_{\xi}K_tR_eK_t'F_{\xi}' + Q_{\xi}$
3. Iterate over 2 until the difference between Ω_t and Ω_{t-1} is small.

Figure 1. Market beliefs to a commodity price shock under perfect and imperfect credibility

— Perfect Credibility MP&FP —○ Imperfect Credibility MP&FP

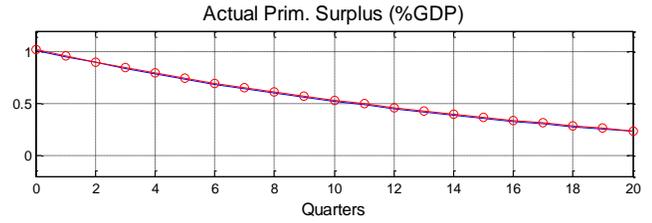
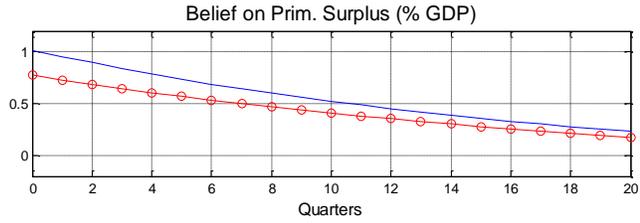
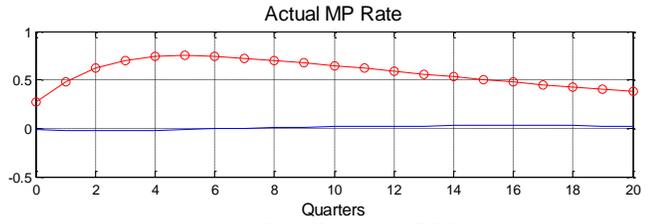
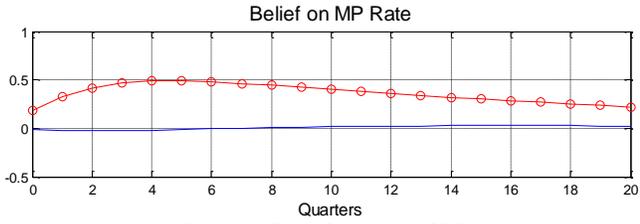
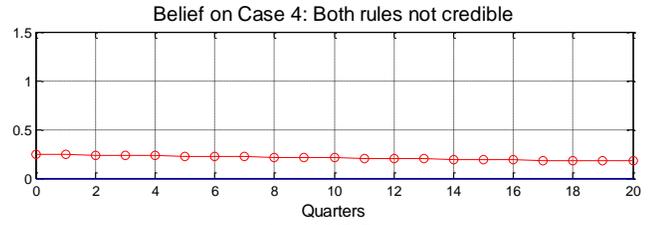
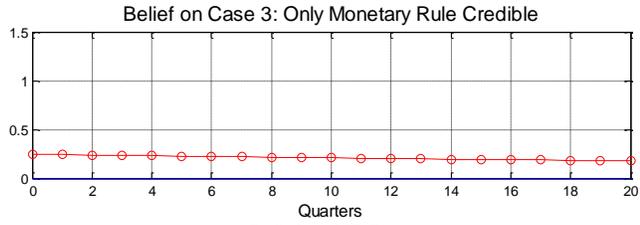
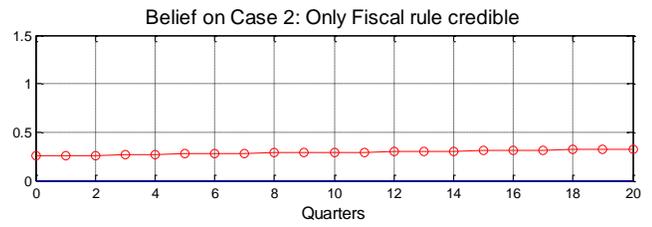
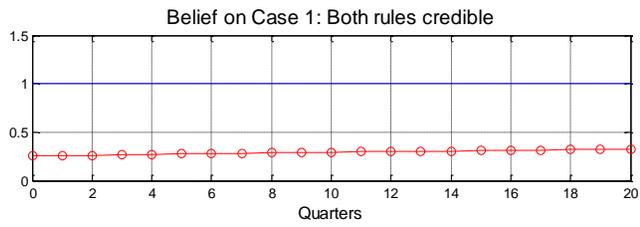


Figure 2. Impulse-response to a commodity price shock under perfect and imperfect credibility

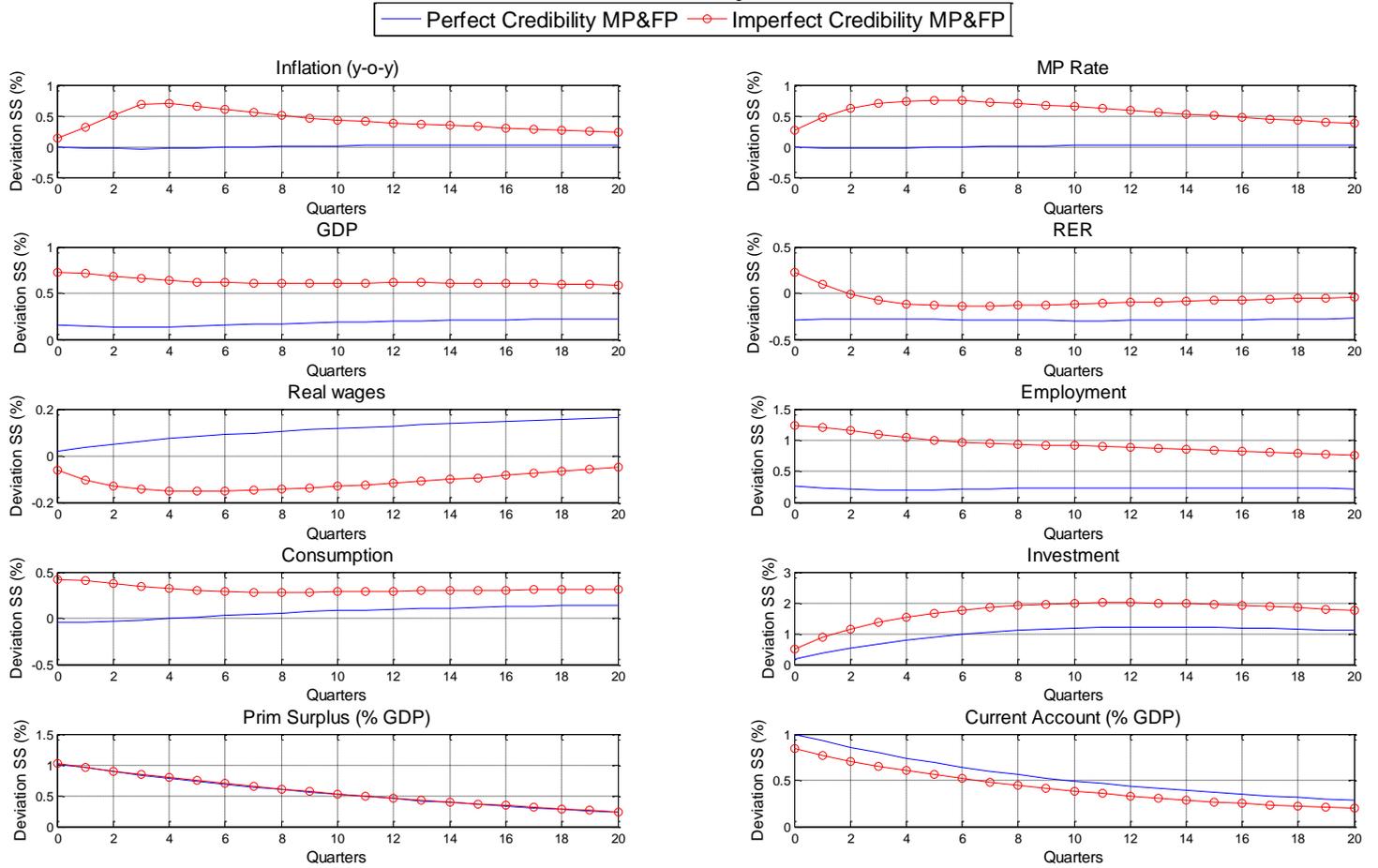


Figure 3. Market beliefs to a commodity price shock under perfect and imperfect credibility. The role of monetary policy transparency

— Perfect Credibility MP&FP — Imperfect Credibility MP&FP — Imperfect Credibility MP&FP+MP Transp

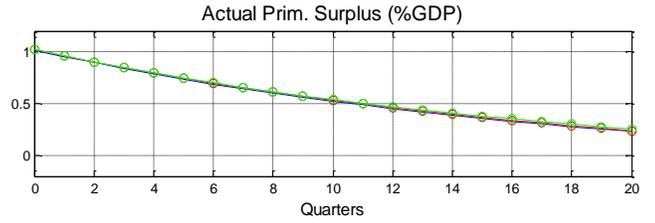
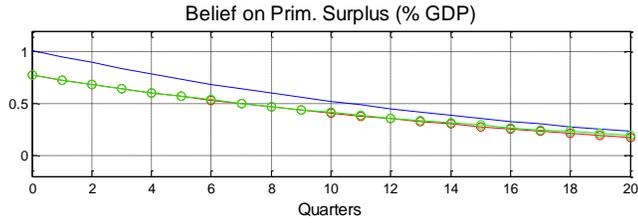
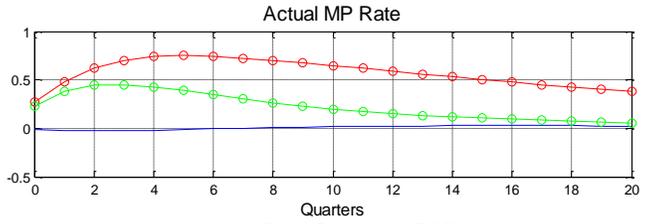
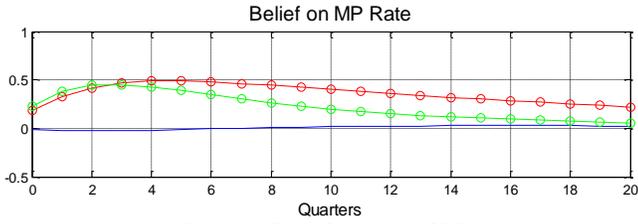
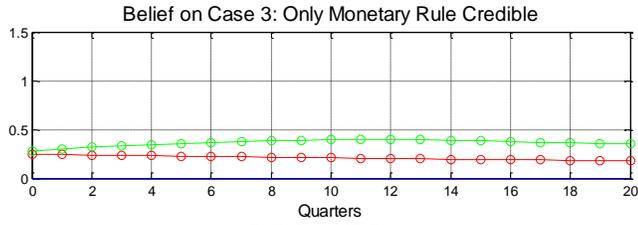
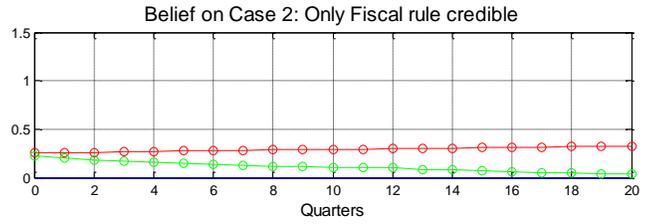
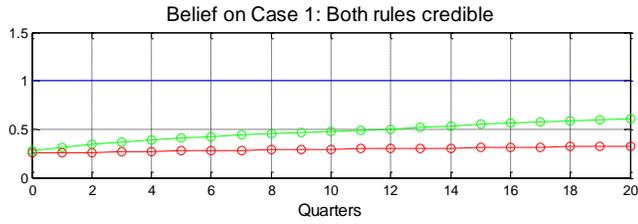


Figure 4. Impulse-response to a commodity price shock under perfect and imperfect credibility. The role of monetary policy transparency.

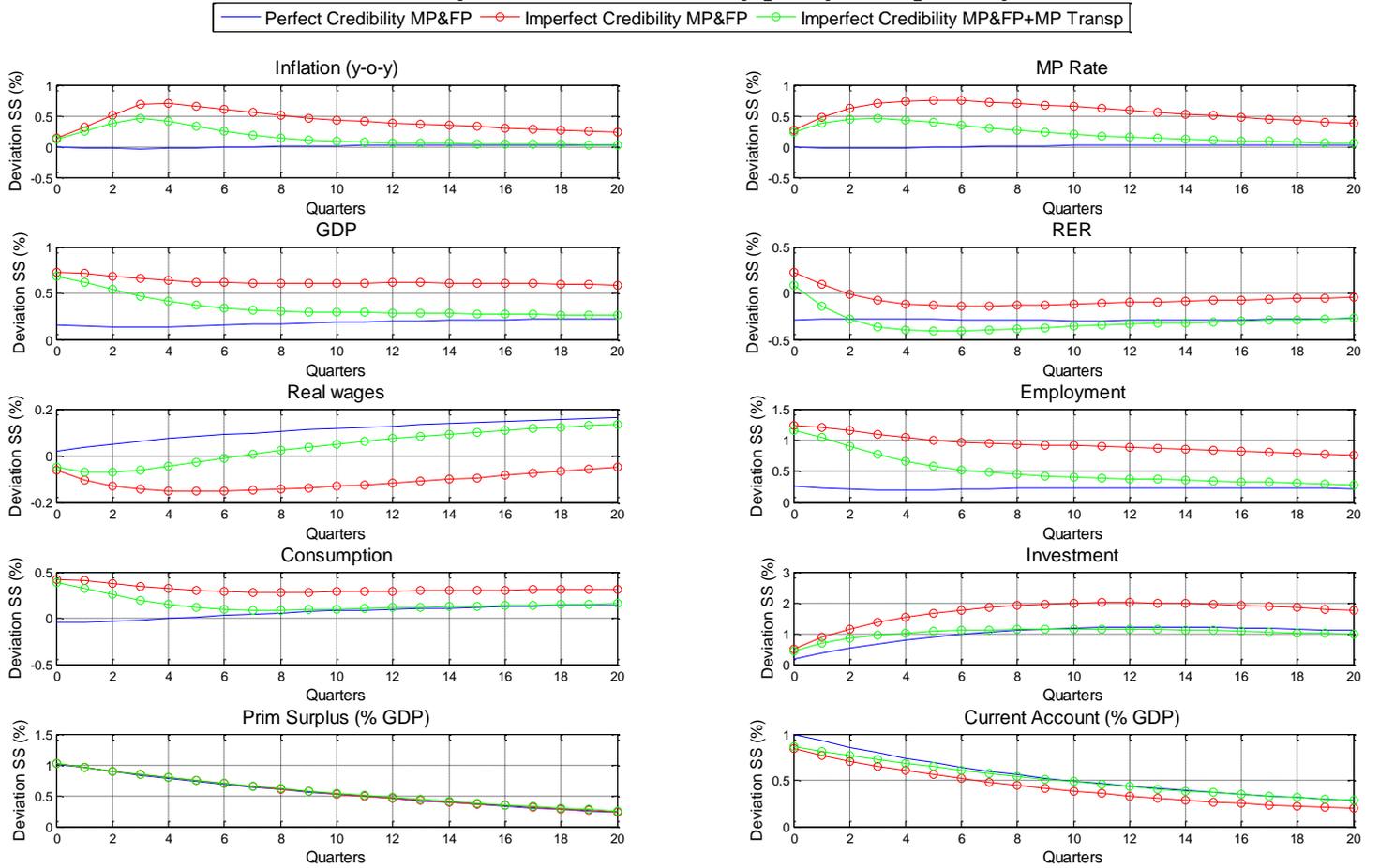


Figure 5. Market beliefs to a commodity price shock under perfect and imperfect credibility. The role of monetary policy transparency and reputation

— Perfect Credibility MP&FP ○ Imperfect Credibility MP&FP+MP Transp. * Imperfect Credibility MP&FP+MP Transp&Reput

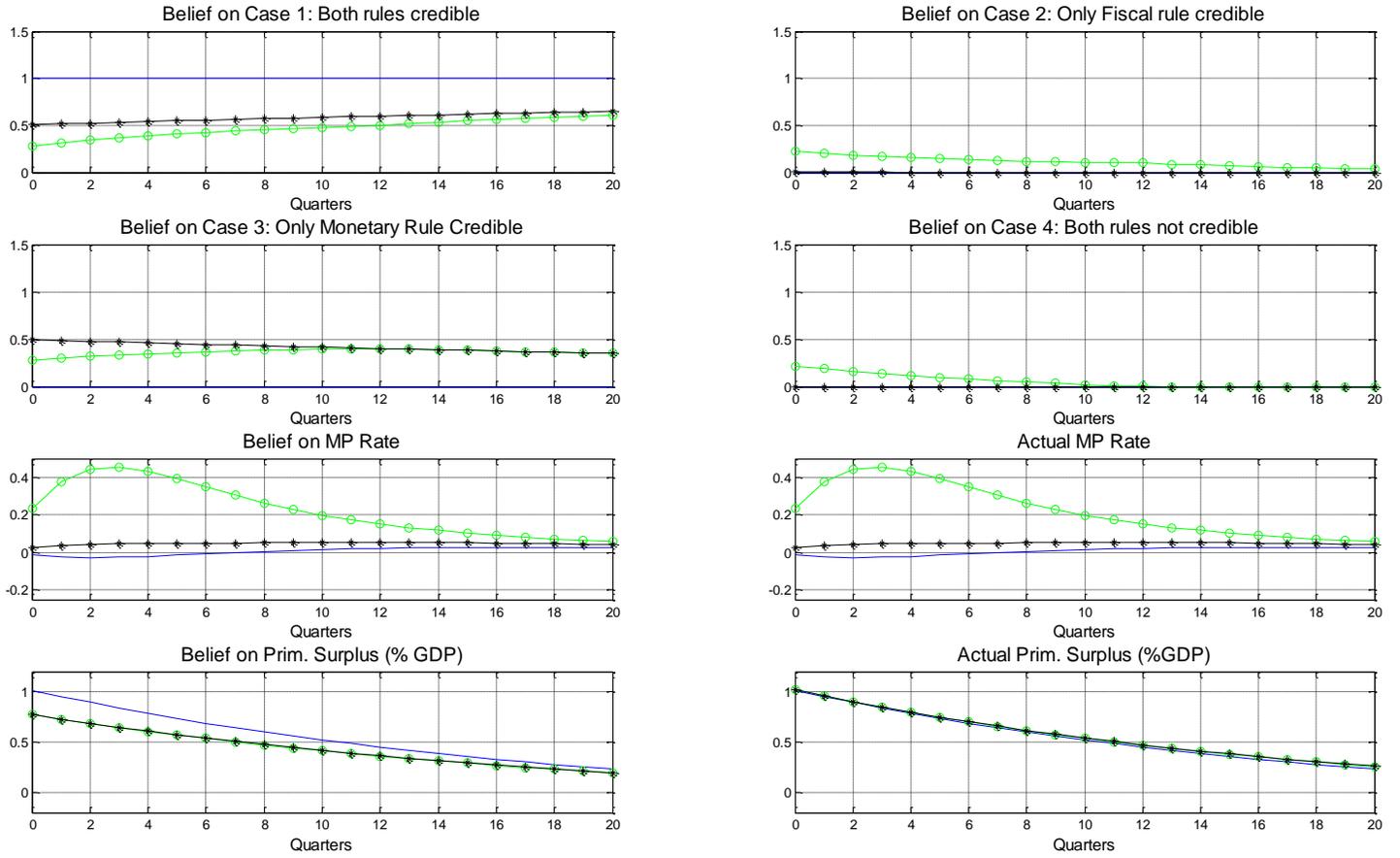


Figure 6. Impulse-response to a commodity price shock under perfect and imperfect credibility. The role of monetary policy transparency and reputation

— Perfect Credibility MP&FP — Imperfect Credibility MP&FP+MP Transp. — Imperfect Credibility MP&FP+MP Transp&Reput

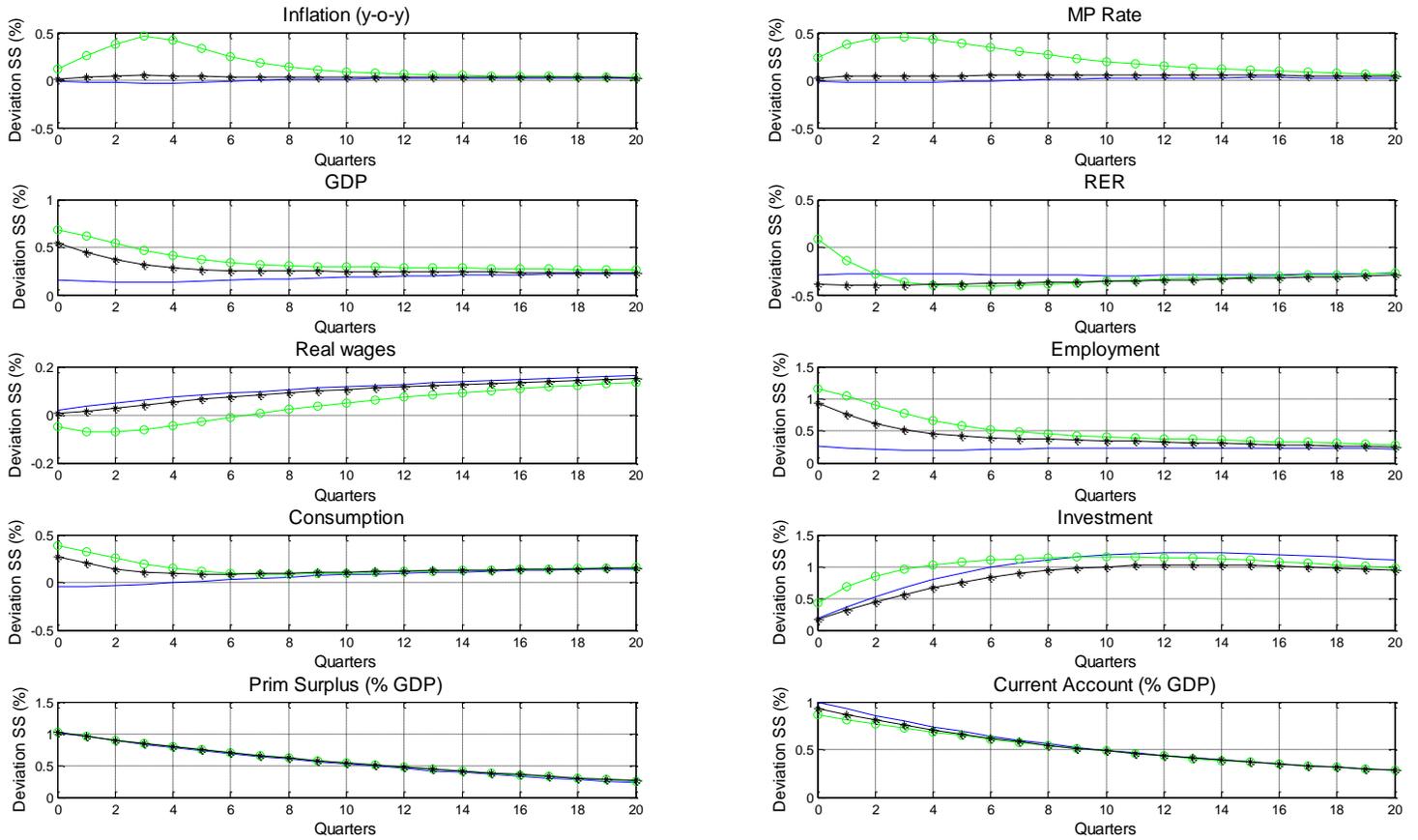


Figure 7. Market beliefs to a commodity price shock under perfect and imperfect credibility. The role of monetary and fiscal policy transparency and monetary policy reputation

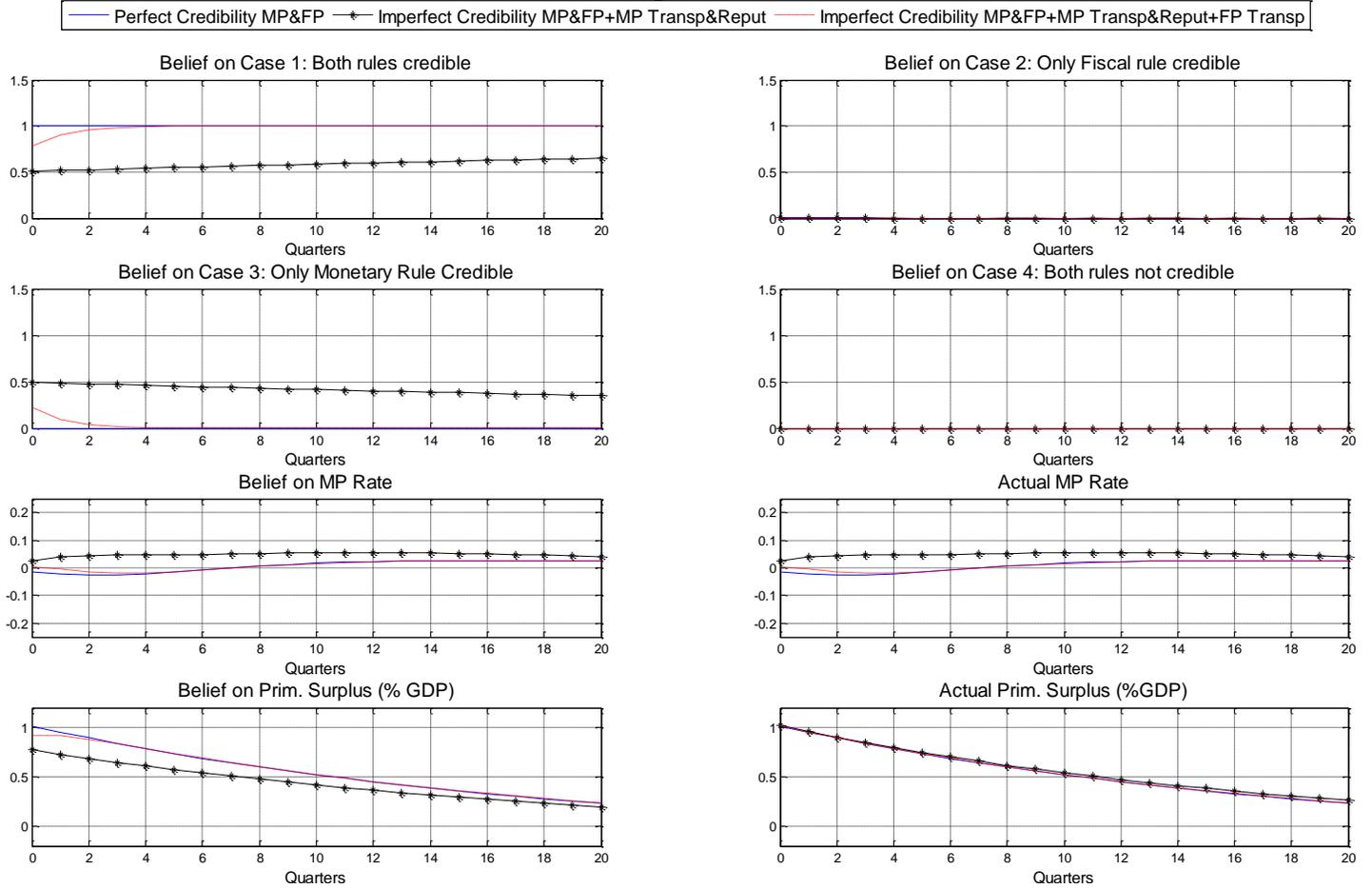


Figure 8. Impulse-response to a commodity price shock under perfect and imperfect credibility. The role of monetary and fiscal policy transparency and monetary policy reputation

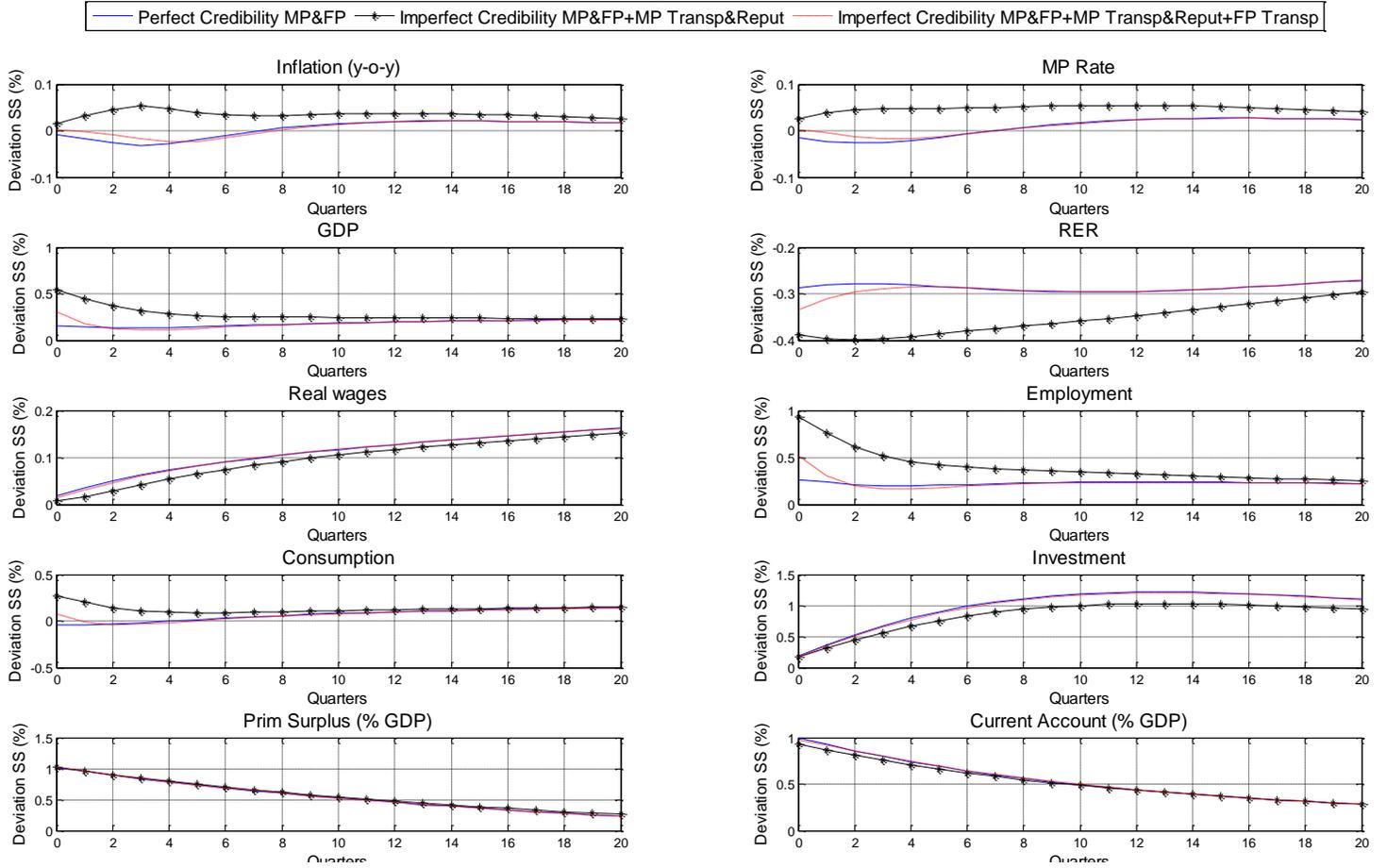
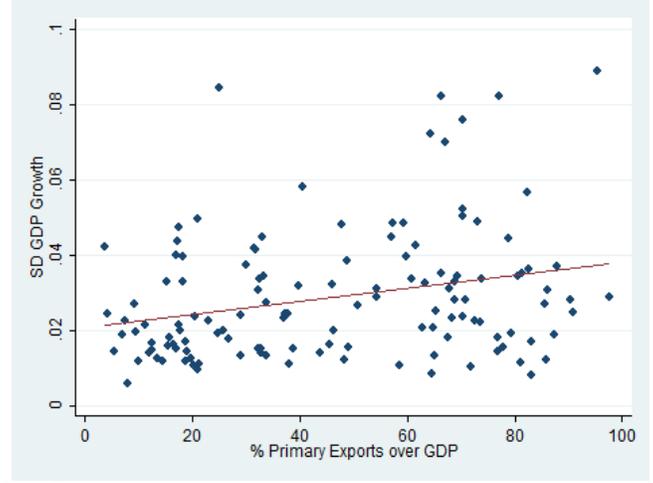
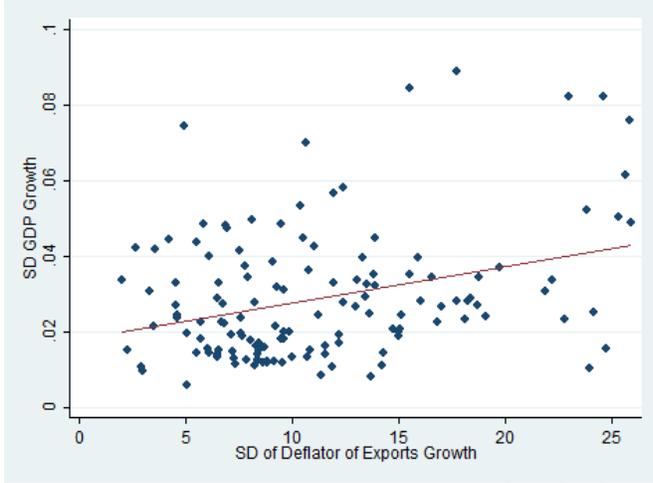
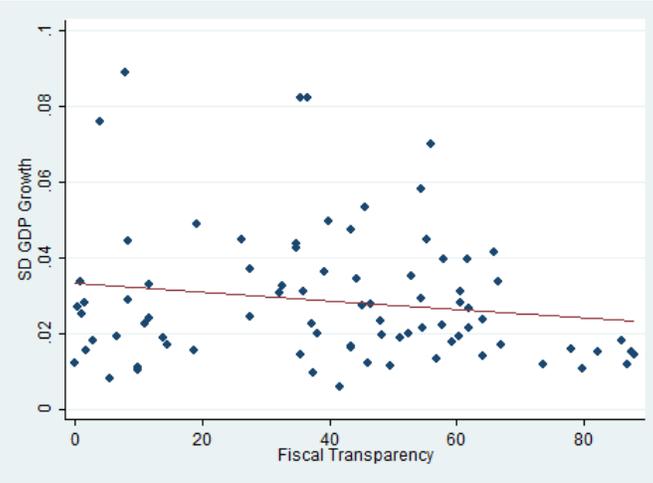


Figure 9. Volatility, Transparency and Credibility

A. GDP growth and export price volatility



B. Growth volatility and Policy Transparency



C. Growth volatility and Policy Credibility

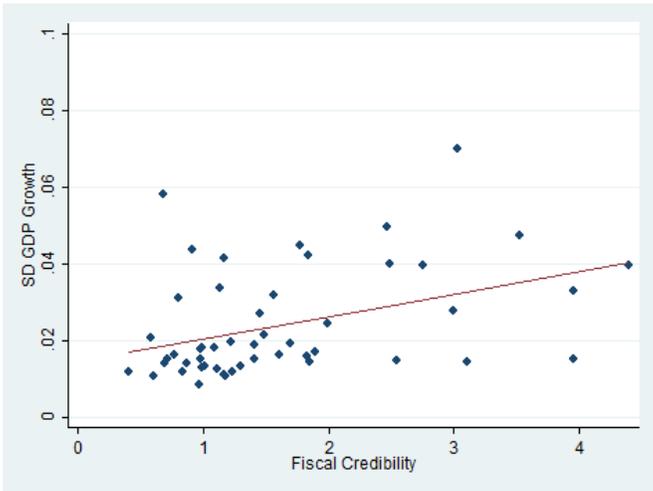
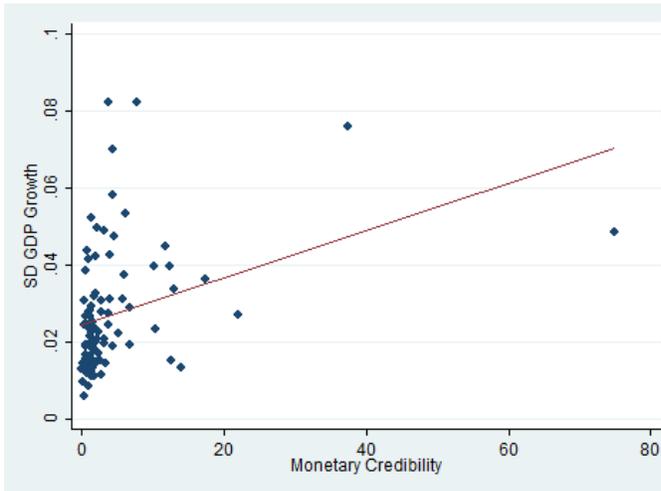


Table 2. Relationship between GDP growth Volatility and Terms of trade Volatility (I)
Dependent variable: Standard deviation GDP growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
SD Exports Defl.	0.000846* *	0.00113***	0.000790**	-0.000899	0.00160***	0.000596**					
	(0.000352)	(0.000265)	(0.000365)	(0.000881)	(0.000306)	(0.000254)					
SD Comm. price							0.000247	0.000169	0.000198	-0.000215	0.000144
							(0.00023)	(0.000203)	(0.000228)	(0.000694)	(0.000170)
SD Exports Defl.	-0.00011*										
X Mon. Transp	(6.10e-05)										
SD Exports Defl.		-4.22e-07									
X Mon. Cred.		(7.72e-07)									
SD Exports Defl.			9.47e-06								
X Fiscal. Transp.			(6.71e-06)								
SD Exports Defl.				0.000289***							
X Fiscal. Cred.				(7.94e-05)							
SD Exports Defl.					-0.00105***						
X Fiscal Rule					(0.000232)						
SD Exports Defl.						-0.000932***					
X Inf. Target						(0.000322)					
SD. Comm. price							-4.12e-05*				
X Mon. Transp.							(2.16e-05)				
SD Comm. price								-3.6e-07***			
X Mon. Cred.								(1.2e-07)			
SD Comm. price									3.3e-07		
X Fiscal Transp.									(2.69e-06)		
SD Comm. price										8.4e-05*	
X Fiscal Cred.										(3.22e-05)	
SD Comm. Price											-0.000192
X Inf. Target											(0.000121)
Constant	0.0301*** (0.00502)	0.0191*** (0.00319)	0.0199*** (0.00623)	0.0291*** (0.00658)	0.0265*** (0.00506)	0.0300*** (0.00424)	0.0292** (0.0126)	0.0266*** (0.00908)	0.0218*** (0.00666)	0.0300 (0.0377)	0.028*** (0.0063)
Observations	90	87	80	31	65	139	23	25	24	7	32
R-squared	0.080	0.194	0.066	0.219	0.053	0.080	0.137	0.042	0.030	0.234	0.081

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. SD Exports Defl. = Standard Deviation of Deflator of Exports Growth; SD Comm. Price = Standard Deviation of Commodity Price Growth.

Table 3. Relationship between GDP growth Volatility and Terms of trade Volatility (II)
Dependent variable: Standard deviation GDP growth

	(1)	(2)	(3)	(4)	(5)	(6)
SD Exports Defl. X % Prim. Exports/GDP	8.49e-06** (3.85e-06)	1.07e-05*** (3.24e-06)	5.24e-06 (4.47e-06)	-5.51e-06 (1.57e-05)	5.02e-06 (3.25e-06)	4.07e-06 (5.93e-06)
SD Exports Defl. X % Prim. Exports/GDP X Mon. Transp.	-1.88e-06* (1.08e-06)					
SD Exports Defl. X % Prim. Exports/GDP X Mon. Cred.		-6.85e-09 (1.98e-08)				
SD Exports Defl. X % Prim. Exports/GDP X Fiscal Transp.			1.17e-07 (1.23e-07)			
SD Exports Defl. X % Prim. Exports/GDP X Fiscal Cred.				4.14e-06** (1.86e-06)		
SD Exports Defl. X % Prim. Exports/GDP X Inf. Target					-2.07e-05*** (6.29e-06)	
Constant	0.0334*** (0.00320)	0.0264*** (0.00229)	0.0280*** (0.00442)	0.0252*** (0.00266)	0.0335*** (0.00335)	0.0300*** (0.00312)
Observations	86	81	76	29	130	59
R-squared	0.042	0.138	0.040	0.184	0.057	0.016

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

SD Exports Defl. = Standard Deviation of Deflator of Exports Growth; SD Comm. Price = Standard Deviation of Commodity Price Growth