Macroeconomic Performance During Commodity Price Booms*

Luis Felipe Céspedes (UAI)

Andrés Velasco (Columbia University and NBER)

March 2012
Preliminary version, do not quote

(*): Prepared for the IMF-CBRT "Policy Responses to Commodity Price Movements" Conference - April 6-7, 2012. We are grateful to Juan Matamala for excellent research assistantship. We are also grateful to Gustavo Adler, Luis Catao, Gian Maria Milesi-Ferretti and Nikola Spatafora for sharing their data with us.

I. Introduction

Booms in commodity prices imply significant challenges for macroeconomic policy in commodity-producing nations. Fluctuations in commodity prices are often associated with macroeconomic volatility. Using a small open economy real business cycle model, Mendoza (1995) estimates that roughly one-half of the variation in aggregate output in a sample of the G7 and 23 developing economies can be attributed to terms of trade shocks. Kose (2002) applies a similar framework and finds that terms of trade shocks can explain almost all of the variance in output in small open developing economies.

But in this regard not all nations are created equal. The macro response to commodity booms and busts depends both on the structural characteristics of the economy and the policy framework that is in place. In this paper we investigate the response of a group of commodity-producing nations in episodes of large commodity prices booms. We center our analysis on the response of output and the real exchange rate to commodity price shocks controlling by the role played by the financial market depth, the exchange rate regime and other usual controls using in the literature.

Commodity price shocks are transmitted to the economy through different channels. One of them is fiscal policy. In Céspedes and Velasco (2011) we revisited the issue of fiscal pro-cyclicality in commodity republics, i.e. countries for which commodity-linked revenues represent a large portion of government revenue. Given that the behavior of commodity prices is plausibly a main driver of fiscal policy outcomes in these countries, we focused on the behavior of fiscal variables across the commodity cycle.

But fiscal policy is not the only factor that matters. There other channels through which terms of trade shocks (or shocks to commodity prices) affect the macroeconomic performance of a country. The theoretical and empirical literature has stressed the role played by exchange rate regime in the transmission of terms of trade shocks to the economy. Under a fixed exchange rate regime, the domestic currency is pegged to another currency or to a basket of currencies while under a flexible exchange rate regime the nominal exchange rate is allowed to move freely in response to supply and demand conditions in the foreign exchange market. In the presence of nominal rigidities, a flexible exchange rate regime helps stabilize the economy in response to terms of trade shocks as the nominal exchange rate adjust immediately to the real shock. The alternative is to wait until nominal wages and goods' prices adjust, increasing the volatility of output and employment.

The empirical evidence tends to support the view that more flexible exchange rate regimes tends to insulate the economy better when facing terms of trade shocks. Broda (2002), using a sample of developing countries, documents that in response to negative terms of trade shocks countries with fixed exchange regimes experience large and significant declines in real GDP and the real exchange rate depreciates slowly. The opposite occurs in the case of flexible exchange rate regimes. Edwards and Levy Yeyati (2003) find evidence that indicate that terms of trade shocks are amplified in countries that have more rigid exchange rate regimes. They also provide evidence of an asymmetric response to terms of trade shocks. In particular, they find that the output response is larger for negative than for positive shocks. Finally, Aghion et al (2008) provide evidence that the impact on productivity growth of terms of trade shocks also depends on the nature of the exchange rate regime. They show that their impact is larger under a fixed exchange rate regime and close to zero under a flexible rates regime.

In this paper we characterize the response of different macroeconomic variables in the episodes of high commodity prices documented in Céspedes and Velasco (2011). First we review the different channels through which shocks to commodity prices affect the domestic economy using a simple open economy model with nominal rigidities and financial frictions. We provide a closed form solution for the output response to a commodity price shock as a function of the degree of exchange rate flexibility and of financial market depth. As expected, the output response is smaller for more flexible exchange rate regimes. We also show that the output response to commodity price shocks goes up as financial development rises from a low level, but it eventually goes down as financial development becomes sufficiently high.

Next, we provide empirical evidence regarding the role played by the exchange rate regime, the development of financial markets, international reserve accumulation and the degree of openness in the transmission of commodity price shocks. We concentrate our analysis on the output dynamics and the evolution of the real exchange rate in those episodes of large commodity prices. We find that, consistent with the theoretical predictions, more flexible exchange rate regimes are associated with smaller responses of output to commodity price shocks. We also provide evidence that the impact of those shocks tends to be larger for economies with financial markets of intermediate levels of development.

Finally, we provide evidence that the response of the real exchange rate to commodity price shocks is larger for more flexible exchange rate regimes. We also find that the rate of international reserve accumulation tends to reduce the appreciation of the real exchange rate in episodes of commodity price booms. At a first glance, this last result may be explained by the fact that less flexible exchange rate regime must accumulate international reserves in order to keep the parity. Nonetheless, when we control for the flexibility of the exchange rate regime, the results hold.

The paper is organized as follows. In the next section we construct a simple model that captures the role of financial constraints, nominal rigidities and the exchange rate regime in the transmission of commodity price shocks. Then we turn to the empirical analysis. We first specify the commodity price indexes used in the analysis and lay out the precise definition of a boom. Then we present regression analysis on the determinants of output and exchange rate dynamics in our commodity boom episodes. A final section offers some preliminary conclusions.

II. A simple model

We construct the simplest model that captures the role of financial constraints, nominal rigidities and the exchange rate regime in the transmission of commodity price shocks to the rest of the economy. The model has two periods, current and future;[1] two produced goods, foreign and domestic; and two kinds of people, capitalists and workers. It borrows from earlier work by Céspedes, Chang and Velasco (2004, 2003), and Velasco (2001).

Output of the domestic good is

$$Y = K^{\alpha} L^{1-\alpha}, \tag{1}$$

where the capital stock K is given by history and labor L is supplied by workers. With this Cobb-Douglas technology, competition and profit maximization by firms causes the wage bill to be equal to a fixed share of nominal output

$$WL = (1-\alpha)PY, \tag{2}$$

where W is the nominal wage and P is the price of domestic output in terms of the domestic currency. If real wages are flexible, workers supply one unit of labor in equilibrium[2]:

$$L = 1 \tag{3}$$

In addition to the two goods that are produced, there is a natural resource endowment of size R that accrues to domestic capitalists. The price of this resource in terms of the foreign good (the dollar price of the resource, if you wish), is given by Q, which is given to the small home economy. The natural resource is not consumed domestically. Therefore the dollar value of natural resource exports in the initial period is QR.

Workers consume domestic and foreign goods, with shares γ and $1-\gamma$ in total consumption. For simplicity, they have no access to borrowing and lending, and consume the whole wage bill:

$$WL = P^{\gamma} S^{1-\gamma} C, \tag{4}$$

where C is a basket of total consumption and $P^{\gamma}S^{1-\gamma}C$ is the price index corresponding to this basket. Notice that since the law of one price holds for foreign goods and their foreign currency (or dollar) price is normalized to one, then S the nominal exchange rate is their peso price. Define $E \equiv S/P$ as the relative price of foreign goods, or *real exchange rate*.

[1] Current-period variables have no time subscripts. Future-period variables have a 1 as subscript.

[2] This can be derived from utility maximization by workers if their objective function is logarithmic in consumption and C.E.S. in labor effort. See Cespedes, Chang and Velasco (2004) and Velasco (2001).

The action in the model primarily involves the capitalists. They consume in the second period only, and (in true capitalist style) they consume only foreign goods. Hence, their objective is to maximize the dollar value of their net worth at the end of next period. They do this by buying capital today, which they finance resorting to their net worth N and to foreign loans F. The capitalists' budget constraint is

$$I = N + EF_1, \qquad (5)$$

where F_1 denotes the amount borrowed abroad to be repaid next period and I investment in real capital. Notice that capital is composed of domestic goods only. If no constraints on their ability to borrow are binding, capitalists maximize their end-of-next period net worth by choosing an amount of investment such that the return to capital is equal to the expected cost of borrowing:

$$\frac{\alpha Y_1}{I} = (1+\rho)(\frac{E_1}{E}) \qquad (6)$$

But crucially, capitalists cannot borrow more than a multiple of their net worth:

$$EF_1 \leq \lambda N, \qquad (7)$$

a condition that may or may not bind in what follows. Combining this last equation with the budget constraint 5 we have

$$I \leq (1+\lambda)N, \qquad (8)$$

which shows that investment can be no larger than a multiple of net worth.

At the beginning of each period, capitalists collect the income from capital (equal to αY), receive their endowment R of the natural resource and repay old foreign debt, whose current home output value is EF. As a consequence, their net worth is

$$N = \alpha Y + E\left[QR - (1+\rho)F\right], \qquad (9)$$

where ρ is the world real interest rate. Note that –holding real income constant— a real devaluation, defined as an increase in E, may increase or reduce net worth, depending on whether the expression $QR-(1+\rho)F$ is positive or negative.

To close the model, markets for the domestic good must clear. In the current period that requires

$$Y = \gamma E^{1-\gamma} C + I + EX, \qquad (10)$$

where X is the exogenous dollar value of exports.[3] Given that the next period is the terminal period and no investment takes place, we have

$$Y_1 = \gamma E_1^{1-\gamma} C_1 + E_1 X_1. \tag{11}$$

Finally, introduce money in the simplest way, using a cash-in-advance constraint on consumption

$$M \leq P^{\gamma} S^{1-\gamma} C, \tag{12}$$

which we will assume binds in what follows. Combining 2, 4, and cash-in-advance constraint 12 yields

$$M / P = (1-\alpha) Y. \tag{13}$$

To allow for an intermediate exchange rate regime (somewhere strict fixing and floating), assume a policy rule so that the money supply follows

$$\frac{M / P}{\overline{M / P}} = \left(\frac{E}{\overline{E}} \right)^{-1/\phi} \tag{14}$$

where $\phi \geq 0$ and where a bar above a letter denotes the flexible price equilibrium. The case of $\phi = 0$ implies fixed exchange rates: money adjusts instantaneously to ensure that the real exchange rate is always equal to its flexible price setting. Conversely, as $\phi \rightarrow \infty$ we have flexible rates: real balances are always equal to their flexible price level, regardless of what happens to the real exchange rate.

This model can be reduced to an extremely simple system of equations. From market-clearing (expression 10) combined with 2 and 4 we have

$$\beta Y = I + EX \tag{15}$$

where $\beta \equiv 1 - \gamma(1-\alpha) > 0$.

Carrying out analogous substitutions using 2, 4 (led one period), 7 and 11 we have

$$\beta I = \alpha E X_1 / (1+\rho), \tag{16}$$

which gives current investment as a function of (the present value of) expected future exports. This is the level of investment that would prevail if arbitrage were possible.

[3] This is similar to Krugman (1999), and can be justified by positing that the foreign intratemporal elasticity of substitution in consumption is one, but that foreigners' expenditure share on domestic goods is negligible.

But arbitrage may not be possible if the financial constraint binds. To see what shape exactly that constraint takes, combine 8 and 9 and arrive at

$$I \leq (1+\lambda)\left[\alpha Y + E\left[QR-(1+\rho)F\right]\right] \tag{17}$$

That completes the presentation of the model. Which variables are endogenous or exogenous depends on whether wages and prices are flexible. With full nominal flexibility, output is exogenous[4], and 15 and either 16 or 17 pin down investment and the real exchange rate regardless of monetary or exchange rate policy. In that case 13 simply residually determines the quantity of real balances and 14 is irrelevant.

But if prices and wages are predetermined (at least in the initial period, where all the action is), then monetary and exchange rate policy matters, and unanticipated shocks to either exogenous variables or policy can have effects on output of the home good, as well as investment and the real exchange rate. In what follows we develop a simple diagrammatic approach to characterize what the sticky-price, sticky-wage equilibrium looks like.

Our goal is to show all relevant determinants of short-run equilibrium in a diagram in *E,Y* space. Combining 14 and 16 we have the levels of output and the exchange rate that would prevail if arbitrage does indeed take place:

$$E = Y\left[\frac{X}{\beta} + \frac{\alpha}{\beta^2}\frac{X_1}{(1+\rho)}\right]^{-1} \tag{18}$$

We call this the AI (arbitraged investment) schedule, which slopes up in *E,Y* space.

In turn, putting together 15 and 18 to eliminate *I* we have the combinations of output and the exchange rate that are feasible if the financing constraint is indeed binding:

$$E \geq Y\frac{\beta-(1+\lambda)\alpha}{X+(1+\lambda)\left[QR-(1+\rho)F\right]} \tag{19}$$

We refer to this as the CF (constrained financing) schedule, which also slopes up in *E,Y* space.[5]

It is easy to see that a sufficient condition for schedule CF to be steeper than schedule AI is for λ to be small enough: if the multiple of their net worth capitalists can borrow is tiny, then CF lies everywhere above AI in *E,Y* space, and any equilibrium must be constrained.

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[4] It is given by production function 2, evaluated at the inherited K and $L=1$ as indicated by 3.

[5] For this to be the case we need $\beta > (1+\lambda)\alpha$, which we assume from now on.

Finally, money demand expression 12 and monetary rule 13 together yield

$$Y/\overline{Y} = \left(E/\overline{E}\right)^{-1/\phi} \qquad (20)$$

We term this the ME (monetary equilibrium) schedule, which slopes down in E, Y space. Notice that under flexible exchange rates ($\phi \to \infty$) schedule ME becomes vertical and output is always at its flexible-price level. Conversely, under fixed exchange rates ($\phi = 0$), ME is horizontal and the real exchange rate is always at its flexible-price level.

Let us now analyze possible equilibria. There are two candidates: unconstrained and constrained. Figure 1A shows the case of an unconstrained equilibrium. The AI schedule lies below the CF schedule. Equilibrium is at point A, where AI cuts ME. Note that in this case a (small) shock to the terms of trade does not affect the position of the equilibrium. The same is true of shocks to the initial level of debt. That is because Q and F only enter the CF schedule, which is irrelevant in this case. Notice, however, that a large adverse drop in Q or a large rise in F could cause the slope of the CF schedule to rise sufficiently, so that the equilibrium became constrained.

In the unconstrained equilibrium the level of external demand for the domestic good does matter for output and the real exchange rate. Figure 1B shows what happens if either current exports X or future exports X1 go up. Schedule AI becomes flatter and now cuts ME at point B. Output of the domestic good goes up and the real exchange rate appreciates.

Alternatively, Figure 2A shows a constrained equilibrium. Now schedule AI lies above schedule CF. Equilibrium is at point B, where CF cuts ME. Note that output of the domestic good is lower and the exchange rate is more depreciated than it would have been if the equilibrium were unconstrained.

In this case the terms of trade do matter for the position of the equilibrium. In particular, a fall in Q causes to the CF schedule to become steeper, reducing output and depreciating the real exchange rate. The intuition is that capitalists' net worth falls, and they can therefore borrow and invest less, so that output is lower. The same effects (qualitatively at least) occur if current exports X drop or initial debt F goes up. These are the cases depicted in Figure 2A.

To make the analysis of the effects of terms of trade shocks more systematic, and to identify interaction effects, we finally consider the linearized version of the constrained equilibrium.

Taking logs of both sides of 19 (assuming strict equality) we have

$$\log E = \log Y + \log\left[\beta - (1+\lambda)\alpha\right] - \log\left[X + (1+\lambda)\left[QR - (1+\rho)F\right]\right] \qquad (21)$$

Taking the total differential of this expression, keeping both export demand and initial debt constant, we have

$$\frac{dE}{E} = \frac{dY}{Y} - \eta \frac{dQ}{Q}, \tag{22}$$

where $\eta \equiv \dfrac{(1+\lambda)QR}{X + (1+\lambda)\left[QR - (1+\rho)F\right]}$.

Applying the same procedure to (20) yields

$$\frac{dE}{E} = -\phi \frac{dY}{Y} \tag{23}$$

Finally, combining these two equations yields

$$\frac{dY}{Y} = \frac{\eta}{1+\phi} \frac{dQ}{Q}, \quad \text{where } \frac{\eta}{1+\phi} > 0 \tag{24}$$

Therefore, the impact of a terms-of-trade shock on output of the domestic good is larger when ϕ is small, so that the exchange rate is relatively fixed. This is intuitive: with sticky wages and prices, flexibility in the exchange rate helps stabilize output. But notice: the larger is η, for instance because initial debt in dollars is large, the more flexible the exchange rate has to be in order to achieve the same degree of stabilization.

Notice also that the effect of the terms of trade on output is also larger when λ is larger, so that η rises. This is also intuitive: the more capitalists can borrow against their net worth, the larger the impact on investment and output of enjoying the additional revenue from exporting the natural resource, which becomes part of net worth.

However, recall that when λ gets to be very large the equilibrium is no longer constrained, and the terms of trade cease to matter for short-term output. This suggests that the correlation between output volatility and terms of trade volatility is hump shaped: it goes up as financial development rises from a low level, but it eventually goes down as financial development becomes sufficiently high.

For instance, take copper producers: a fall in the price of copper matters more for non-copper producers in Chile (medium financial development) than in Zambia (low financial development), but in Australia (high financial development) it matters less than in Chile.

Notice also that the impact of Q on Y is large when F is large (so that η is large). The intuition is that the associated real devaluation hurts more when there is a larger debt denominated in foreign goods (dollars, say), because net worth falls more and therefore – in a financially constrained equilibrium— investment falls more as well.

Finally, notice also that the impact of terms of trade shocks on output is larger when *QR* is larger (so that η is larger as well).[6] This is because when the natural resource is a large part of net worth, then an increase in the price matters more for the ability of capitalists to borrow and invest. This is intuitive. Continue with the example of copper: the effect of a drop in the price on copper producers should be larger in Chile, which produces a lot of copper, than in Argentina, which produces much less.

III. Empirical section

In this section we present empirical evidence on the effects of commodity price shocks on macroeconomic performance. We focus our analysis on episodes of large commodity price booms. We define those episodes as periods in which an index of country-specific commodity prices surpasses its historical trend by a certain threshold margin.

In Cespedes and Velasco (2011) we construct a commodity price index for a group of 35 economies, using as weights the share of commodity *i*' production in total commodity production in country *j*. This strategy differs from the common procedure of using as weights the share of the share of commodity *i*' exports in total commodity exports in country *j*.

The advantage of our strategy is that allows us to compute and update the weights beginning early last century. This is not possible with commodity export shares, which are only available from a much later date. This is relevant given that, as we will see later, a significant share of commodity price boom episodes took place in the late 1960s and 1970s.

The disadvantage of our strategy is that we must leave out some countries due to data restrictions. To get around that, in this paper we complement the production-based commodity index with an export-based commodity index along the lines of Spatafora and Tytell (2009), Deaton and Miller (1996) and Cashin, Cespedes, and Sahay (2004). In particular, we use a commodity price index constructed using the weights of the relevant commodity exports in total exports. We deflate this commodity export price index by the producer price index for the United States. This alternative allows us to incorporate a larger group of countries in our empirical analysis.

Following earlier work (Cespedes and Velasco (2011)) we define a commodity boom episode as a period during which our measure of commodity price index reaches a level at least 25% above its trend. The trend is computed using a centered moving average with a 50-year window in the case of the production-based index and a HP filter in the case of the export-based index.

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[6] This last effect requires $X > (1+\lambda)^{-1}(1+\rho)F$, meaning that exports of the home good have to be sufficiently high relative to debt service.

Each episode begins in the first year in which the index surpasses the trend and ends in the year prior to the index returning below the trend. Using the production-based commodity index we obtain 58 episodes for a total of 31 countries. In the case of the export-based commodity index we have 95 episodes for a total of 59 countries. For those countries with both indexes, the episodes that we found are almost identical.

Most of the commodity price boom episodes are concentrated around two main periods: one taking place in the 1970s and early 1980s, and another in the years immediately prior to 2008. Given than the most recent episodes are still ongoing we study the macroeconomic performance in the boom phase. In particular, we define an episode for our empirical purposes as the period that goes from the beginning to the peak in our commodity price index. We assume that the peak of the last episode was 2008.

A. Output performance during commodity price boom episodes

The first objective of our analysis is to test the response of economic activity to commodity price shocks, taking into account the potential role of the exchange rate regime and the degree of financial development as discussed in our theoretical section. For this purpose, we construct a measure of the output gap using the HP filter. In order to reduce the end point problem that arises with this method (and which may be particular relevant for those episodes ended in 2008), we extend our GDP series from 2010 to 2016 using the latest WEO forecast of GDP growth for the countries in our sample.

In our theoretical section we summarize the role of exchange rate flexibility through the parameter ϕ. Larger values for that parameter imply more exchange rate flexibility. Our empirical counterpart for that parameter comes from Ilzetzki, Reinhart and Rogoff (2008)'s exchange rate system classification. In our analysis we use 13 different categories constructed by these authors indexed from 1 to 13 according to the degree of exchange rate flexibility, with higher values indicating more flexibility.[7]

In order to measure financial development we follow the conventional approach of using credit to the private sector (as % of GDP) as a proxy. In order to avoid potential endogeneity problems, we use the value of this variable in the two years previous to the beginning of the episode.

Our first set of regressions has the following structure:

$$\Delta y_i = \alpha + \beta \Delta COM_i + \gamma(\Delta COM_i \times ERR_i) + \mu_i$$

[7] In the exchange rate clasification constructed by Ilzetzki, Reinhart and Rogoff there are 14 categories: no separate legal tender, pre announced peg or currency board arrangement, pre announced horizontal band that is narrower than or equal to +/-2%, de facto peg, pre announced crawling peg, pre announced crawling band that is narrower than or equal to +/-2%, de factor crawling peg, de facto crawling band that is narrower than or equal to +/-2%, pre announced crawling band that is wider than or equal to +/-2%, de facto crawling band that is narrower than or equal to +/-5%, moving band that is narrower than or equal to +/-2%, managed floating, freely floating and freely falling. In our analysis we ignore the freely falling category in a similar way than Aghion, Bacchetta, Ranciere, and Rogoff (2009).

where Δy_i is the average output gap during the episode i minus the average output gap in the two years previous to the beginning of episode i; ΔCOM_i is the percent change in the average commodity price index during the episode i with respect to the average commodity price index in the two years previous to the beginning of episode i; and ERR_i is the exchange rate classification for the country during the episode i. The interaction term reflects our theoretical discussion that suggests that higher exchange rate flexibility tends to reduce the impact of commodity price shocks on economic activity. The equation is estimated by weighted least squares.

The results are in table 1. In some of the estimations we use a dummy that takes value 1 for the most recent episodes and 0 otherwise. We also study additional controls by including a trade openness measure (that corresponds to the average fraction of exports plus import as % of GDP in the two years previous to the beginning of episode i) and a capital account openness measure from Chinn and Ito (2008). In the case of the commodity price change we use the export-based index and the production-based index. Given the larger sample size of the former index, we report it in the first place.

The commodity price increase is positively associated with economic activity in our sample of commodity price booms. The importance of the exchange rate regime on output dynamics, captured by the interaction of the exchange rate classification variable and the change in the commodity price index, turns out to have the expected sign and is significant in most of the specifications.

The results tend to be larger and more robust when we concentrate in economies with financial markets of intermediate levels of development, which we define as economies where private credit as % of GDP is higher than 15% but lower than 70%. This result tends to be consistent with our theoretical model, which indicates that there is a hump shaped response of output to commodity price shocks depending on the degree of financial development. Nonetheless, we do not have a significant amount of episodes in our sample for economies with highly developed financial markets, which do not allow us to be conclusive on this result.

For the sample of commodity price booms obtained using the production-based commodity price index the results are quite similar to those obtained using the export-based commodity price index.

B. Real exchange rate adjustment to commodity price shocks and international reserve accumulation

In this subsection we study how the real exchange adjusts to the commodity price increase in our boom episodes. The mechanisms through which commodity price shocks affect the economy in general, and the real exchange rate in particular, are varied. In the theoretical section we provided a general framework to analyze the impact of those shocks in the economy. In this general open economy framework, a commodity price shock tends to appreciate the real exchange rate and that the impact on the real exchange rate is larger when the exchange rate regime is more flexible .

In this empirical subsection we add one factor that has received significant attention, though there is little agreement on its effect: international reserves accumulation as a proxy for foreign exchange interventions.

Aizenman, Edwards and Riera-Crichton (2011) study whether active management of international reserves affects the transmission of international price shocks to real exchange rates, using a sample of Latin American countries. They provide evidence that indicates that active reserve management lowers the short-run impact of terms of trade shocks and affects the long-run adjustment of the real exchange rate. Adler and Tovar (2011) using a panel for 15 countries find that interventions can slow the pace of appreciation, although the effect decreases rapidly with the degree of capital account openness. They document that interventions appear to be more effective when there are signs that the currency could already be overvalued.

Using the commodity price boom episodes described in previous section we run the following regression:

$$\Delta REER_i = \alpha + \beta \Delta COM_i + \gamma \Delta R_i + \mu_i$$

where $\Delta REER_i$ is the percent change of the average real exchange rate during the episode *i* with respect to the average real exchange rate in the two years previous to the beginning of episode *i*. A positive value for this variable means an appreciation of the real exchange rate. ΔCOM_i is the percent change of the average commodity price index during the episode *i* with respect to the average commodity price index in the two years previous to the beginning of episode *i*. Finally, ΔR_i is the difference between average international reserves (as % of GDP) during the commodity boom episode and average international reserves (as % of GDP) in the two years previous to the beginning of episode *i*.

In our analysis we do not use foreign exchange interventions but international reserves changes. We know that reserves vary not only due to foreign exchange interventions, but also due to valuation changes and income flows, debt operations on behalf of other agents, among others. However, this is likely to be a major problem in estimations using high frequency time series. This problem should be lower in our episode approach.

Results are reported in table 2. The results indicate that there is a significant impact of the commodity terms of trade of the real exchange rate. For the whole sample, a ten percent increase in the commodity price index is associated with an appreciation between 1.3 and 2 percent. These coefficients are in the lower range for the results founded in previous studies (see Chen and Rogoff (2004), Cashin, Céspedes, and Sahay (2004), and Ricci, Milesi-Ferretti and Lee (2008), among others).

We also run our set of regressions for a different subsample of countries. In particular, we circumscribe our estimation to the more flexible exchange rate regimes in the Ilzetzki, Reinhart and Rogoff (2008)'s classification. Our results are consistent with our previous result that the impact of commodity price shocks is larger for more flexible exchange rate regimes.

Next we consider a formulation that is closer to the spirit of our theoretical section. In particular, we claimed that the impact of the commodity price shock on the real exchange rate depends on the degree of exchange rate flexibility. In order to test that prediction of the model we interact the commodity price increase during episode *i* with the exchange rate regime classification constructed by Ilzetzki, Reinhart and Rogoff (2008). As discussed before, that classification associates the different regimes to a number between 1 and 13, with larger numbers reflecting higher exchange rate flexibility. The results we obtain indicate that in effect the impact of the commodity price shock on the real exchange rate is increasing in the degree of exchange rate flexibility.

Regarding the impact commodity price shocks in economies with financial markets of intermediate levels of development, there is no significant difference to the results obtained using whole sample.

Finally, we also find a significant impact of reserve accumulation on real exchange rate dynamics. Our estimations indicate that the accumulation of international reserves tends to reduce the appreciation of the real exchange rate. Acknowledging the endogeneity problem that arise in this estimation from the simultaneity between the intervention decision and the contemporaneous exchange rate, it is important to notice that that endogeneity problem leads to obtain small and incorrectly signed coefficient on contemporaneous interventions (see Kearns and Rigobon (2005)). That is not the case in our estimations.

The negative coefficient between the real exchange rate change and the accumulation of international reserves may be explained by the fact that less flexible exchange rate regime must accumulate international reserves in order to keep the parity. Nonetheless, when we control by the flexibility of the exchange rate regime, the results hold. The results are robust to the inclusion of other controls in the regression, such as degree of trade openness, financial development and capital account openness. Our results indicate that an accumulation of 10% of GDP in international reserves would tend to depreciate the real exchange rate by 5%.

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Table 1: Output dynamics in commodity price boom episodes

Explanatory variable	Dependent variable: change in output gap									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Commodity price index change	0.009	0.013	0.031	0.038	0.030	0.035				
	(0.66)	(0.75)	(2.31)**	(2.76)***	(2.61)***	(3.08)***				
Exchange rate flexibility*commodity price index change	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.004	-0.005
	(-1.60)	(-1.41)	(-2.85)***	(-2.99)***	(-2.71)***	(-3.28)***	(-2.18)**	(-2.33)**	(-1.83)*	(-2.15)**
Trade openness			0.008							
			(0.56)							
Capital account openness				-0.004						
				(-1.03)						
Financial development										
Commodity price index change (PB)							0.018	0.027	0.030	0.035
							(1.13)	(1.66)*	(2.77)***	(2.77)***
Exchange rate flexibility*commodity price index change (PB)										
Dummy episode		0.022	0.020	0.026		0.027		0.032		0.038
		(2.56)**	(1.83)*	(2.29)**		(2.76)***		(2.85)***		(2.60)**
R2	0.02	0.10	0.14	0.15	0.07	0.20	0.06	0.19	0.09	0.29
Number of observations	88	88	67	67	59	59	54	54	33	33
F test	1.78	3.00**	2.71**	2.49**	4.38**	5.01***	2.46*	3.08**	3.21*	3.67**
Sample	All	All	All	All	Private credit (% GDP)>15% and <70%	Private credit (% GDP)>15% and <70%	All	All	Private credit (% GDP)>15% and <70%	Private credit (% GDP)>15% and <70%

Al regressions are estimated using a constant, t test in parenthesis. PB: Production-based commodity price index.
(***);(**);(*), significance levels at 1%,5% and 10% respectively.

Table 2: Real exchange rate adjustment in commodity price boom episodes

Explanatory variable	Dependent variable: change in real exchange rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Commodity price index change	0.130 (1.94)*	0.167 (2.15)**	0.194 (2.29)**	0.128 (1.95)*		0.274 (2.70)***	0.156 (1.88)*
International reserves change	-0.401 (-2.32)**	-0.415 (-2.16)**	-0.482 (-2.62)**	-0.405 (-2.33)**	-0.449 (-2.37)**	-0.708 (-3.61)***	-0.316 (-1.8)*
Trade openness		0.004 (0.05)					
Capital account openness			-0.030 (-1.12)				
Financial development				-0.033 (-0.50)			
Exchange rate flexibility*commodity price index change					0.026 (2.14)**		
R2	0.08	0.10	0.13	0.08	0.16	0.18	0.16
Number of observations	88	71	71	87	83	60	59
F test	3.58**	2.76**	2.99**	2.39*	0.16**	7.04***	2.97*
Sample	All	All	All	All	All	More flexible ERR	Private credit (% GDP)>15% and <70%

Al regressions are estimated using a constant, t test in parenthesis.
(***);(**);(*), significance levels at 1%,5% and 10% respectively.

Figure 1A: Financially Unconstrained Economy

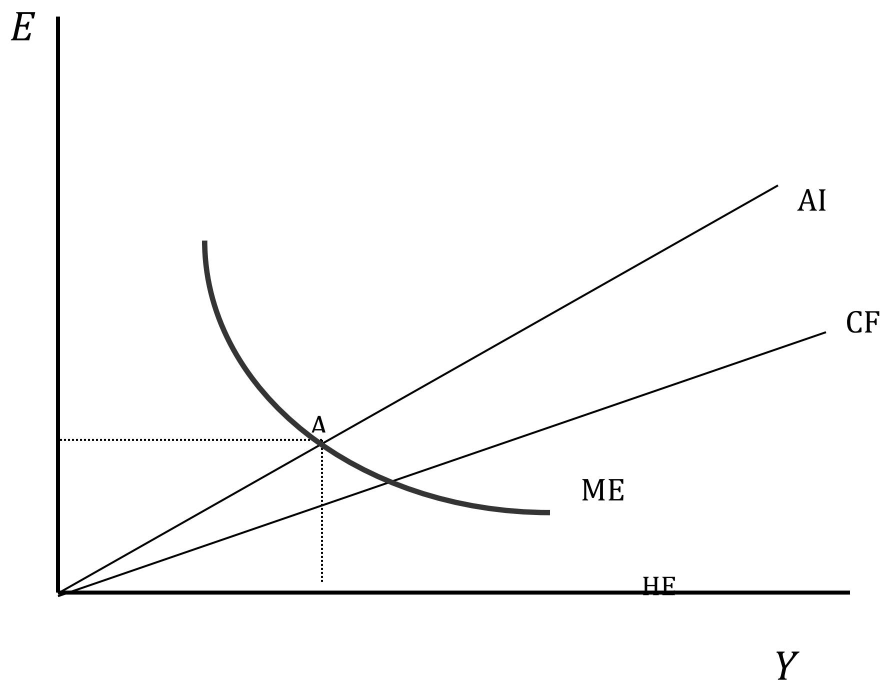

Figure 1B: Terms of Trade Drop in a Financially Unconstrained Economy

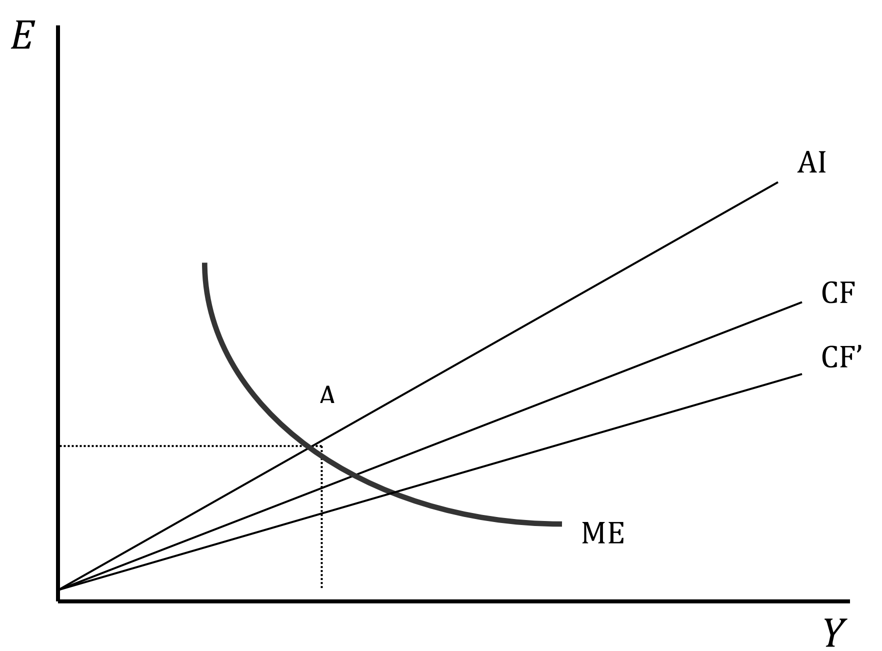

Figure 2A: Financially Constrained Economy

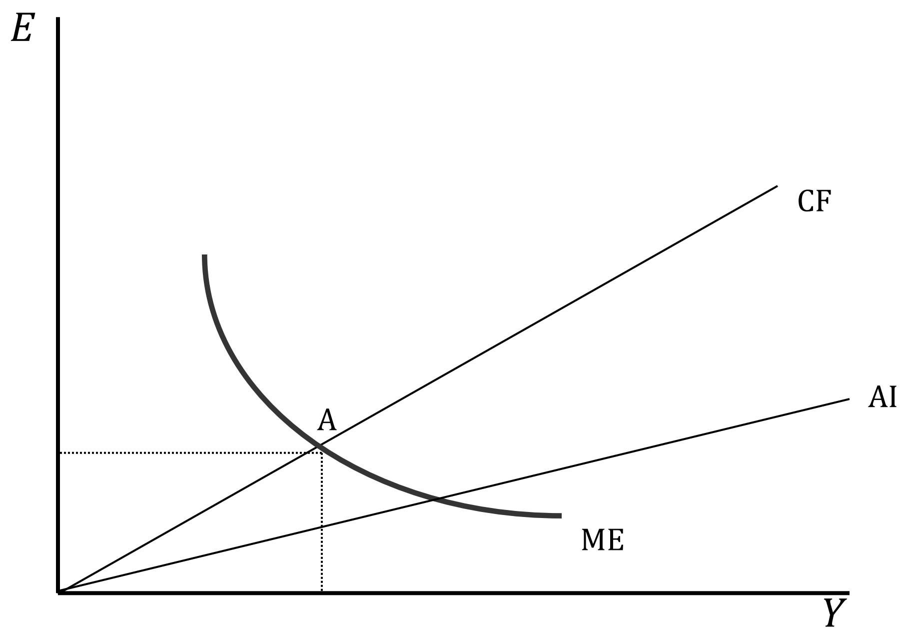

Figure 2B: Terms of Trade Drop in a Financially Constrained Economy