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Commodity Prices and Business Cycles in Paraguay

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Paraguay is a small open economy and a net commodity exporter. The difference between commodity exports and imports has always been positive and remained on an upward trend since 1994. Net commodity exports scaled by GDP increased from around 4.8% in the second half of the 90s to approximately 10% in the last 5 years. In addition, food commodities averaged 90% of total commodity exports in the period 1994-2017. In this Bulletin, we build a Paraguayan-specific commodity price index and quantify its relative importance as driver of business cycles in Paraguay.

We conduct a quantitative analysis to gauge the relative importance of commodity price shocks in driving the business cycle in Paraguay. For this purpose, our analysis adopts the small open economy model of Drechsel and Tenreyro (2018) (DT hereafter). We choose their model since their extension analyzes the case of a net commodity exporting country facing exogenous international price changes and allows a double role of commodity prices: the "competitiveness effect" and "borrowing cost effect". To capture the first effect, the authors include two productive sectors in their model: the commodity producer-exporter and the final good producer that imports commodity inputs. To illustrate the second effect, the authors embed a negative relation between the interest rate premium and commodity prices, consistent with the empirical evidence that a rise in commodity prices tend to improve borrowing terms for net commodity exporters.

Empirical regularities

This section presents the main empirical features that characterize the business cycle of Paraguay's economy from 1994:Q1 to 2018:Q1.

We begin our characterization by documenting business cycle moments. As the table shows, business cycles in Paraguay have the common property of a high correlation between output, consumption and investment and the higher volatility of investment. Similar to other emerging countries, consumption is more volatile than output and the trade balance is countercyclical.

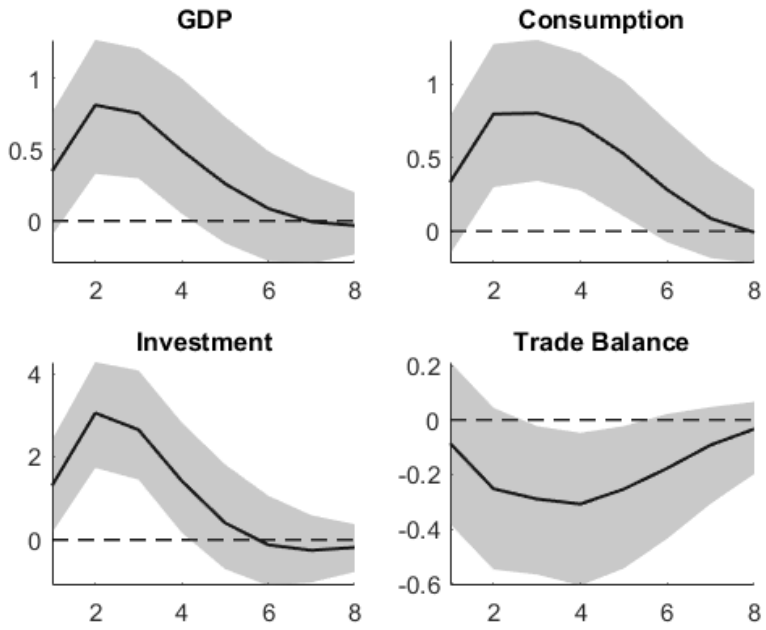
Table 1. Business cycle moments 1994:Q1 to 2018:Q1

	GDP growth	Consumption growth	Investment growth	Trade Balance	Trade Balance (yearly diff.)
Standard deviation (%)	4.228	4.295	10.758	2.524	2.486
Standard deviation relative to S. D. GDP growth	1.000	1.016	2.544	0.597	0.588
Persistence	0.525	0.464	0.576	0.720	0.4000
Correlation with GDP growth	1.000	0.689	0.734	-0.312	-0.011

Notes: GDP, consumption and investment are in real terms and expressed as annual growth rates. Trade balance is total exports minus total imports, scaled by GDP. Frequency of the data is quarterly.

We now turn to estimate a SVAR and find that the dynamic effects of an exogenous shock in commodity prices is similar to those observed in other emerging countries. Figure 1 presents impulse response functions to a one standard deviation shock to commodity prices. There is a statistically and economically significant positive response of output, consumption and investment. The total trade balance response is negative, particularly three quarters later than the occurrence of the shock. Measured at peak, a one standard deviation shock in international commodity prices increases GDP growth rate by around 1 percent.

Fig. 1. Impulse responses to 1 S.D. commodity price shock



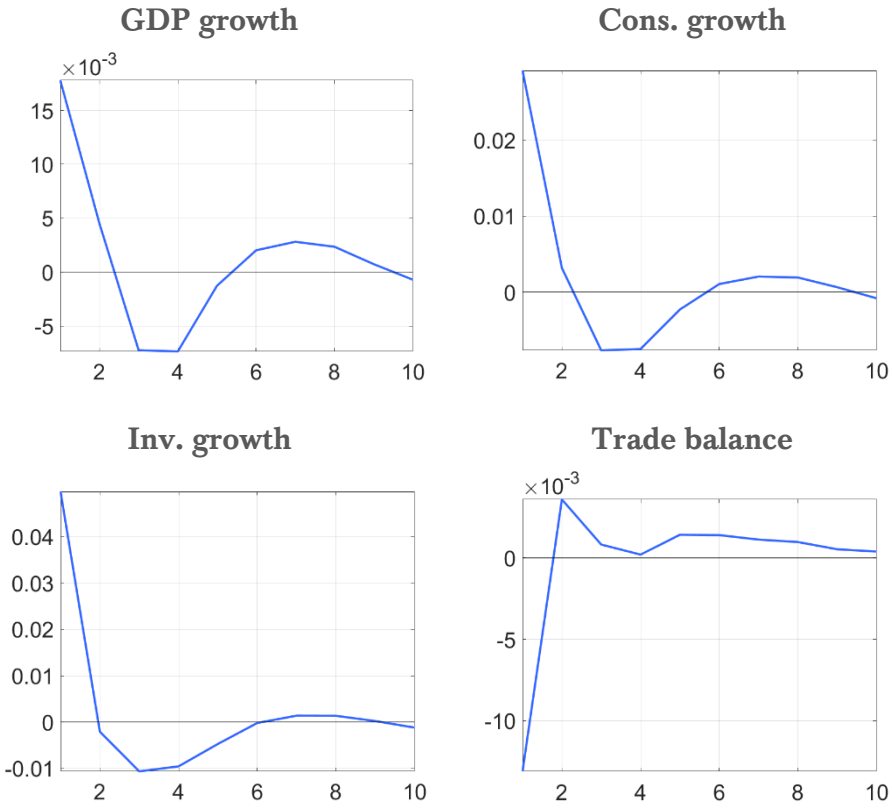
Note: The structural shock is identified using Cholesky ordering and we assume the commodity price index is exogenous to domestic variables at all lags. Grey bands represent 90% confidence bands. GDP, consumption, investment are real and expressed as anual growth rates. Trade balance is defined as the yearly difference.

Calibration exercise and aggregate domestic dynamics following commodity price fluctuations.

To explain the dynamics that arises from commodity shocks, we calibrate parameters following DT but using data from Paraguay. We first calculate the following key ratios (averages during 1995-2017): commodity net exports (7%), trade balance (4.87%), government spending (11.19%) and investment to GDP (19%). These serve as target to calibrate steady state values of prices of commodity exports, debt, government spending and annual depreciation rate. We use average GDP annual growth rate (3.4%) to calibrate steady state value of growth in productivity and joint with the steady state of real interest rate (10%) will determine the discount factor in utility function. To present impulse response functions to commodity price shocks, we calibrate the stochastic process of commodity prices using the estimated SVAR coefficients.

Figure 2 displays the impulse response functions to a commodity price shock. Responses on impact are in line with stylized facts of business cycles of Paraguay. Positive commodity price shocks boost the economy by increasing output, consumption and investment growth. The consumption response is larger in magnitude than output response. The total trade balance response is negative, implying countercyclical net exports.

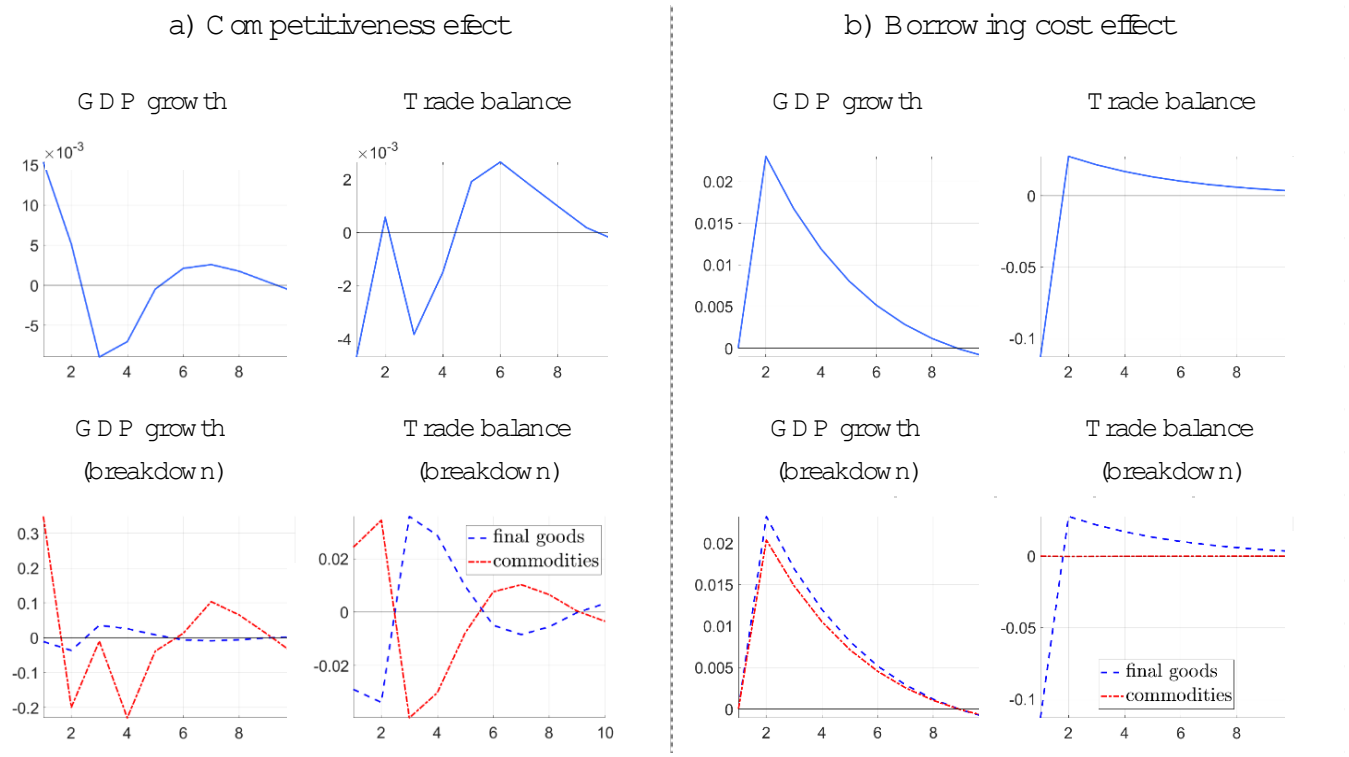
Fig. 2. Model Impulse response functions to a one standard deviation commodity price shock



By shutting down the real interest rate channel, Figure 3a illustrate the "competitiveness effect" of an increase in commodity prices. Higher international prices increase trade revenues and production in the commodity sector. At the same time, higher prices make commodity inputs more expensive and thus decreases production in the final good sector. As the boom in the commodity sector exceeds the contraction in final good production, the net effect on output is positive. As net exports by sector move in opposite directions and almost cancel each other, the net effect on trade balance is only slightly negative. The presence of an impact response in output and consumption stand in contrast with the empirical impulse responses and suggests that this channel alone cannot mimic the data.

Figure 3b Illustrate the "borrowing cost effect" of an increase in commodity prices. Higher international prices decrease the cost of borrowing and allow households to increase investment and final good consumption (both domestic and imported). As imports of consumption goods rise, net exports of final goods decline on impact. The subsequent rise in capital stock will boost production in both sectors. The slow and hump-shaped response of output is consistent with empirical impulse responses. However, the strong response of the trade balance stand in contrast with the data. This finding suggests we need to include both channels to get closer to the data.

Fig. 3. Breakdown of IRFs: double role of a one standard deviation of commodity price shocks



Estimation: assessing the quantitative contribution of different sources of shocks in Paraguay.

We retrieve aggregate series of gross domestic product, final private consumption, gross fixed capital formation and the trade balance from the National Accounts Statistics Department at the Central Bank of Paraguay. The sample covers the years 1995 to 2018 at quarterly frequency. We express all variables except the trade balance ratio as annual growth rates of the corresponding series at constant prices (national base year 2017). We express the trade balance ratio as the difference between net exports scaled by GDP and the same ratio one year earlier. In addition, we construct a Paraguayan-specific commodity price index deflated by the US consumer price index.

Fig. 4. Paraguayan-specific commodity price index (log dev. from mean)

We maintain the calibration of almost all parameters mentioned earlier. In addition, due to a relatively short sample size, we also fix all autoregressive parameters of stochastic processes at the mean values found by DT for Argentina, except those pertaining to commodity prices and non-stationary productivity. We estimate all remaining parameters using Bayesian techniques. In particular, we

estimate those governing the sensitivity of real interest rate to commodity prices and level of debt fluctuations and standard deviations of all exogenous disturbances. We follow DT in choosing standard prior distributions as commonly used in the literature. By fixing parameters at the posterior modes found by the MCMC algorithm, we then compute forecast error variance decomposition as well as historical variance decomposition of the observables.

How large is the relative contribution of commodity price shocks to variation in output, consumption and investment growth?

Estimates suggest that commodity price shocks can explain an important fraction of output growth (11.52%), consumption growth (15.5%), investment growth (20.49%) and annual changes in the trade balance ratio (14.92%). Indeed, commodity prices fluctuations are at least the third most important source of shocks for all aggregate variables considered.

Consistent with Garcia-Cicco et al. (2010), our estimation also attributes most of the variation in output growth (69.12%) to transitory technology shocks. However, aligned with DT findings for Argentina, we do not confirm their conclusion regarding the small contribution of shocks to nonstationary technology. Our estimates suggest that these shocks explain 14.52% of the variation in output growth in Paraguay and constitute its second most important source of shocks.

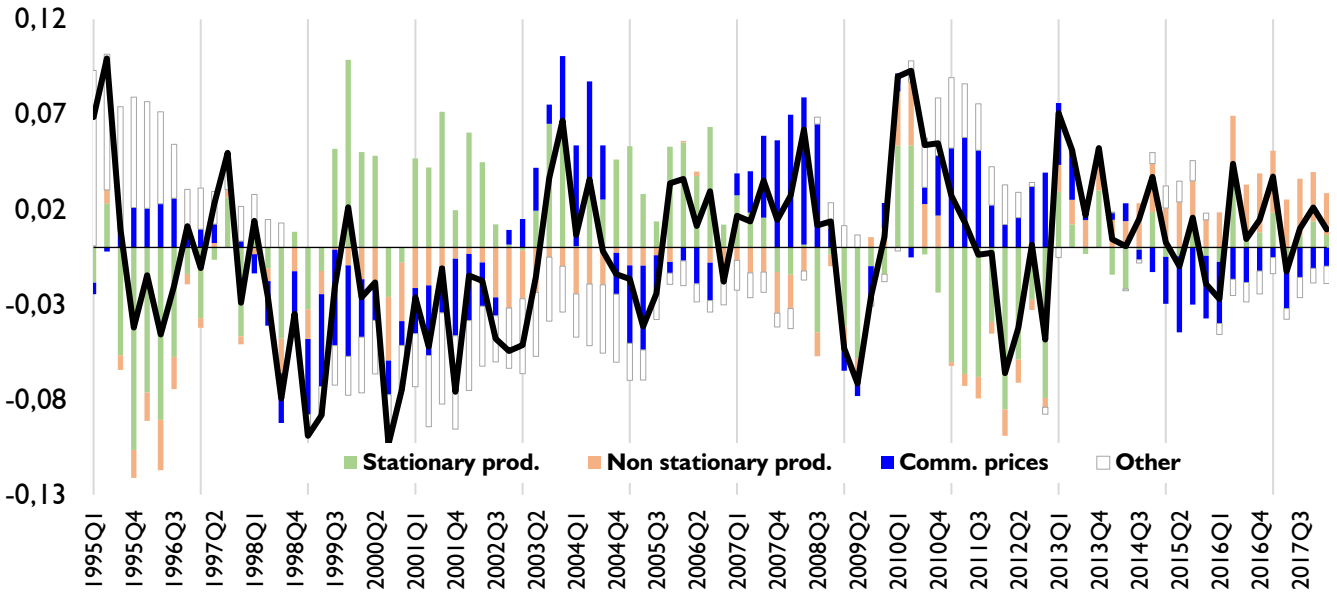
Table 2. Variance decomposition (%)

	Stationary technology	Nonstat. technology	Spending shock	Interest Rate	Pref. shock	Comm. prices
GDP growth	69.12	14.54	0.18	2.1	2.54	11.52
Cons. growth	37.59	10.78	1.17	5.52	29.44	15.5
Inv. growth	15.77	11.25	1.55	35.37	15.57	20.49
Trade Balance	1.40	3.02	6.34	53.66	20.66	14.92

Notes: Forecast error variance decomposition (at infinite horizon) of the observables used for estimation, calculated at the posterior modes.

Finally, we construct the historical variance decomposition of output growth for the period 1995 to 2018. Figure breaks down the movements of output growth (black line) into the contribution of stationary productivity shocks, non-stationary productivity shocks, commodity prices and others. Overall, productivity shocks captures most of the variation in GDP growth. However, we can observe commodity prices also played a very important role, particularly during the 1998-2002 period of low prices, the commodity price boom in 2007 and more recently, the end of the commodity super cycle in 2015. Interestingly, since 2015 and as the unfavorable price environment for net commodity exporters persisted, positive non-stationary productivity shocks (trend shocks) prevented larger declines in the Paraguayan GDP growth rate.

Fig 5. Historical decomposition of output growth 1995-2017



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Appendix

Table A1. Model calibration using Paraguayan data

Parameter	Value	Calibration target/source
$\bar{p}$	0.508	Target commodity net exports to GDP in the data (7%)
d^*	0.197	Target trade balance to GDP in the data (4.87%)
s	0.025	Target gov't spending to GDP in the data (11.19%)
ξ	-0.110	Spread sensitivity to commodity prices (estimates from regression in Appendix)
g	1.034	Average GDP growth in the data
δ	0.126	Annual depreciation rate of capital stock. Target Investment to GDP in the data approx. 19%
β	0.971	Steady state interest rate approx 10%
$\rho_{\bar{p}}{}^1$	0.940	Estimated SVAR coefficient
$\rho_{\bar{p}}{}^2$	-0.552	Estimated SVAR coefficient
$\sigma_{\bar{p}}$	0.118	Estimated SVAR coefficient

Notes: Other parameters not presented here calibrated as Drechsel and Tenreyro.

Table A2. Estimated parameters, priors and posterior estimates

Parameter	Prior	Mean	Std. Dev.	Posterior mean	90% HPD	interval
$-\xi$	Normal	0.199	0.045	0.0687	0.0421	0.0948
ψ	Normal	0.5	0.2	0.7437	0.4038	1.0726
ρ_g	Beta	0.5	0.2	0.6999	0.5481	0.8565
ρ_p^1	Beta	0.8	0.1	0.9673	0.9459	0.99
ρ_p^2	Beta	0.15	0.1	0.0565	0.0209	0.0901
$\sigma_{\{\epsilon_a\}}$	Inverse Gamma	0.05	2	0.0344	0.0284	0.0404
$\sigma_{\{\epsilon_{\bar{a}}\}}$	Inverse Gamma	0.05	2	0.0304	0.0124	0.049
$\sigma_{\{\epsilon_g\}}$	Inverse Gamma	0.05	2	0.0207	0.0137	0.0275
$\sigma_{\{\epsilon_v\}}$	Inverse Gamma	0.05	2	0.5686	0.4978	0.6379
$\sigma_{\{\epsilon_s\}}$	Inverse Gamma	0.05	2	0.1805	0.1514	0.2091
$\sigma_{\{\epsilon_\mu\}}$	Inverse Gamma	0.05	2	0.0266	0.0219	0.0311
$\sigma_{\{\epsilon_{\bar{p}}\}}$	Inverse Gamma	0.05	2	0.1775	0.1551	0.1991