(Il)legal commodities booms: Not all commodities are the same

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Abstract

This paper asks how changes to different international commodities prices affect small open economies. It highlights the differences between mining, agriculture, cattle, and illegal crops. Using quarterly data for legal commodities prices, retail cocaine prices in the US, and the Colombian economy between 1994 and 2010, we show (1) The effects on real economic activity differ when considering mining, agriculture, cattle, or cocaine prices. (2) Shocks to mining and cattle prices produce increases in aggregate demand and a real exchange rate appreciation. (3) The effects of legal and illegal commodities booms differ for the labor market: cocaine price shocks increase employment, reduce wages, and produce a real exchange rate depreciation. In the second part of the paper, we develop a model with four production sectors consistent with our empirical facts to rationalize our empirical findings.

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1 Introduction

An extensive literature shows that fluctuations in commodities prices can explain a large proportion of the business cycle variation in countries with high commodities exports.[1] However, this literature has made one crucial assumption: all commodities markets are the same. In this paper, we revisit this question and ask what are the effects of changes to different commodities prices for a small open economy. Are there differences between mining, agriculture, and cattle? Are the effects different between legal and illegal commodities markets? In particular, are the effects different in order of magnitude and sign? To answer these questions, we use quarterly data for legal commodities prices, retail cocaine prices in the US, and the Colombian economy between 1994 and 2010. Using these data, we show that the nature of the commodity price shock matters. The effects on real economic activity differ when considering mining, agriculture, cattle, or cocaine prices. First, we shock that shocks to mining and cattle prices produce increases in aggregate demand and a real exchange rate appreciation. On the contrary, if something, agriculture and cocaine prices shocks increase investment. Second, we show that the effects of legal and illegal commodities booms differ for the labor market. Cocaine price shocks increase employment, reduce wages, and produce a real exchange rate depreciation. In the second part of the paper, we develop a model with four production sectors consistent with our empirical facts to rationalize our empirical findings.

Colombia is well known for being the largest producer of cocaine.[2]. Moreover, Colombia, like many developing economies, is also known for exporting a variety of legal commodities: Coffee, Bananas, Coal, and Oil, among others-[3]. In this sense, in the first part of the paper, we estimate a partially identified FAVAR model that includes legal commodities prices, cocaine prices in the U.S.., and real economic activity variables.

In the first part of the empirical section, we use principal component analysis to

[1]See for example, Fernández et al. (2017); Hove et al. (2015); Shousha (2016); Mendoza (1995); Schmitt-Grohé and Uribe (2018)

[2]The Bureau for International Narcotics and Law Enforcement Affairs estimates that 90% of the cocaine that enters the United States comes from Colombia (Bureau for International Narcotics and Law Enforcement Affairs, 2007)

[3]Exports of commodities have represented around 40% of the exports since 1998, and above 50% before this time. Source: DIAN (Office for Customs and Taxes) and Banco de la República (Central Bank of Colombia))

construct a vector of price indexes summarizing legal commodities prices. To construct this vector, we use data on commodities that Colombia exported between 1990 to 2010. Our list of commodities includes petroleum, coal, coffee, flowers, bananas, gold, cane sugar, copper, shrimp, palm oil, and fish. We summarize these prices in three factors. The first factor contains mostly mining goods. The second factor summarizes cattle goods, and the third summarizes agricultural goods. Once we have our factor, following a similar identification strategy than Fernández et al. (2017), we measure the effects of commodities shocks, legal and illegal, on GDP, consumption, investment, trade balance, employment, wages, and real exchange rate. This strategy consists of separating the system into two blocks of variables. The first block corresponds to international commodities prices and is exogenous to the Colombian economy. There, we include both types of prices, legal commodities and illegal commodities. The second block is specific to the domestic economy.

We find that not all commodities are the same. These differences are important regarding aggregate demand, labor market, and international trade. In response to a one standard deviation mining and cattle shocks, GDP permanently increases for almost half the standard deviation. In contrast, the effect is mildly negative for an equivalent agriculture or cocaine prices shock.

When we focus on the labor market, the effects are remarkably different. In response to a one standard deviation shock, employment increases to mining and a cocaine price shock, and it is less responsive to cattle and agricultural shocks. However, wages have a different response. In response to legal commodities price shocks, wages increase by one-fifth of a standard deviation in the short term. In contrast, when cocaine prices increase by one standard deviation, wages permanently decline by almost half of a standard deviation.

We also show that the real exchange rate depreciates due to mining and cattle shocks, making the country relatively cheaper. This result is consistent with higher consumption and GDP. On the other hand, in response to a cocaine price shock, there is a permanent real exchange rate appreciation of the same magnitude as the shock.

In the second part of the paper, we develop a small open economy model with tradable and non-tradable goods to rationalize empirical findings regarding the different responses of real economic activity to commodities prices shocks. This economy trades with the rest of the world using manufacturing goods, also used for investment, and raw commodities: mining, agriculture, and illegal crop. Legal commodities differ in their use of land, capital, and labor. The illegal crop only uses a fixed land factor. The sources of uncertainty in the model are changes to commodities prices. The key characteristic of the model is that the illegal sector uses part of its profits to finance domestic investment, thus affecting the supply of capital. In equilibrium, shocks to cocaine prices change labor supply and wages. Shocks to agriculture and mining play different roles because each sector differs in its labor intensity and land use.

We calibrate the model to the Colombian economy and use the models to counterfactuals. First, our empirical results do not get a result close to the so-called "Dutch disease". We ask the model how similar all sectors need to be to switch workers away from manufacturing and into mining and agriculture. In particular, we want to understand if the presence of the illegal sector plays any role in preventing these movements of the factors of production.

Related Literature. This paper contributes to two types of literature. First, it contributes to the literature exploring the effects of trade shocks and commodities booms in developing economies (Schmitt-Grohé and Uribe, 2018; Fernández et al., 2017; Mendoza, 1995; Hove et al., 2015). It adds the effects of an illegal market and improves the effects of commodities by identifying a dynamic factor (Stock and Watson, 2005). Second, it contributes to the literature on the economic impact of illegal markets and civil wars. In particular, it adds to the results in Angrist and Kugler (2008), Steiner (1998), and Dube and Vargas (2013)

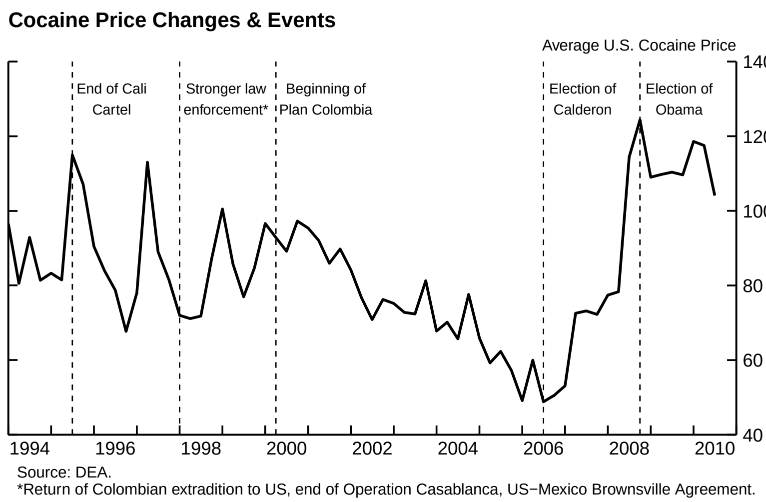
The remainder of the paper proceeds as follows. Section 2 describes the data. Section 3 describes the empirical strategy and establishes the main empirical results. Section 4 describes the model and the simulations. Section 5 concludes.

2 Data

We use four sources of quarterly data from 1994 to 2010: Legal commodities prices from the IMF Primary Commodity Price System and Colombian commodities exports from COMTRADE, retail cocaine prices in the U.S. from the World Drug Report 2010 Shousha (2016), and real economic measures from the Colombian Department of Statistics -DANE- and Haver.

We restrict our sample of legal commodities price indexes deflated using the U.S.. consumer price index to all basic commodities that explain 90% of Colombia's exports between 1994 and 2010. Our list of commodities includes petroleum, coal, coffee, flowers, bananas, gold, cane sugar, copper, shrimp, palm oil, and fish.[4]

Figure 1: Evolution of U.S. retail Cocaine Prices



Note: This figure shows the evolution of U.S. quarterly cocaine prices. Each vertical line shows an important event in the World War Against Drugs. The first line in 1995 is the end of the Cali Cartel, and the second line is a declaration in 1997 of stronger law enforcement in the U.S. against drug consumption. Third, we have the beginning of "El Plan Colombian in 1999' – an aid program of the U.S. government to Colombia to fight drug cartels. The fourth line is the election of Calderon in Mexico, who declared the strongest commitment in his fight against drug cartels, and the last line is the election of Barack Obama as the U.S. President. We use data from the U.S. from the World Drug Report 2010 Shousha (2016).

We measure cocaine prices using data from the U.S. from the World Drug Report 2010 Shousha (2016). In this report, they collect quarterly cocaine prices from 1984 until 2007 with different purity levels in major U.S. cities. Shousha (2016) estimate prices from the System's records to Retrieve Information from Drug Evidence (STRIDE) and maintained by DEA and ONDCP office. Among the prices estimated in this study, we use the prices per gram of Powder cocaine when purchases exceed 50 grams. Figure 1 shows the evolution of the price. This figure highlights major events related to the war against drugs. From the figure, it is worth highlighting that between 1999 and 2006, cocaine prices sharply declined. This period coincides with the moment when the Governments of the United States and Colombia signed an agreement of cooperation to fight the supply chain of cocaine. This agreement is called "El Plan Colombia" and consisted of monetary transfers from the U.S.. government

[4]Table 2 shows the total share of commodities exports and the standard deviation.

to Colombia formulated for military and intelligence expenses to fight the production of cocaine. Between 2000 and 2007, the U.S. Government transferred 5552 million dollars, equivalent to 1.5% of Colombia's GDP per year. Mejía (2009) claims that the reason for this result is the lack of territorial control of the Colombian government on the areas of cocaine production in addition to a reduction of cocaine consumption in the U.S.. Bureau for International Narcotics and Law Enforcement Affairs (2007).

Our third block of data contains real economy activity measures. We use real GDP (Y), consumption (C), investment (I), trade balance (TB), employment rate (L), average hourly wages (W), and real exchange rate (ReR). GDP, consumption, investment, and trade balance are in real per-capita terms. We use standardized growth rates for each variable except for TB, which we only standardize. To compute the series of quarterly GDP and components, we use data from DANE. Using two different series of quarterly GDP: one from 1994 to 2010, and and the second from 2000 to 2015, we construct one historical series. We use the growth rates of the 1994-2007 series to bring the level of the 2000-2015 series back to 1994. We use population and exchange rate data from Haver to compute per-capita measures in US 2010-Q4 dollars. We compute the the trade balance using imports and exports. Table 3 shows summary statistics for these variables.

3 Disentangling the effects of different commodities prices on the real economic activity

3.1 Methodology

We use an autoregressive structure to estimate the effect of legal and illegal commodities price shocks on real economic activity. Ideally, we would like to know the effect of changes in each commodity price -all legal and illegal- on real economic activity. The problem is that we would have almost as many variables as our sample size making our inference imprecise. To address this issue, we use principal component analysis to summarize all legal prices into a vector of latent factors. Using these factors, we then estimate a VAR with three groups of variables as follows:

$$x_t = \begin{bmatrix} \hat{F}_t & cp_t & y_t \end{bmatrix} \tag{1}$$

F_t is a latent variable of factors summarizing legal commodity prices, cp_t price of cocaine, and y_t is a vector of Colombia's real economic activity variables. The structural VAR follows:

$$B_0 x_t = \alpha + B_1 x_{t-1} + \cdots + B_l x_{t-l} + \mu_t \tag{2}$$

Our key identification assumption to estimate equation 2 is that Colombia is a small open economy and cannot affect any commodity price. This assumption implies that B_0^{-1} from 2 has the form:

$$B_0^{-1} = \begin{bmatrix} \mathtt{x} & 0 & 0 & 0 & 0 \\ 0 & \mathtt{x} & 0 & 0 & 0 \\ \mathtt{x} & \mathtt{x} & \mathtt{x} & 0 & 0 \\ \mathtt{x} & \mathtt{x} & \mathtt{x} & \mathtt{x} & 0 \\ \mathtt{x} & \mathtt{x} & \mathtt{x} & \mathtt{x} & \mathtt{x} \end{bmatrix} \tag{3}$$

It is important to highlight that since we are not interested in identifying any of the additional shocks besides commodity shocks, the order of the VAR variables in y_t is irrelevant. What matters to our identification is that cocaine price shocks and legal commodities price shocks are independent. With these assumptions, we can re-write the system in the reduced form VAR to estimate impulse responses and forecast error variance decomposition using OLS following:[5]

$$\hat{F} = A_1 \hat{F}_{t-1} + \cdots + A_l \hat{F}_{t-l} + \mu_t \tag{4}$$

$$pc_t = \tilde{A}_1 pc_{t-1} + \cdots + \tilde{A}_l pc_{t-l} + \tilde{\mu}_t \tag{5}$$

$$\begin{aligned} y_t = {} & B_1 \hat{F}_{t-1} + \cdots + B_l \hat{F}_{t-l} + \tilde{B}_1 pc_{t-1} + \ldots + \tilde{B}_l pc_{t-l} \\ & + C_1 y_{t-1} + \cdots + C_l y_{t-l} + \tilde{D} pc_t + D\hat{F}_t + \epsilon_t \end{aligned} \tag{6}$$

[5]We test this hypothesis using an exogeneity test. We can not reject the null hypothesis that the Colombian macroeconomic variables and commodities prices are not exogenous to cocaine prices, nor the hypothesis that Colombian macroeconomic variables and cocaine are not exogenous to the cocaine prices.

We estimate the model using two lags, $L = 2$. We use a wild bootstrap technique to estimate the confidence intervals to allow for conditional heteroskedasticity. We conduct 10000 replications and present 90% and 95% confidence intervals.

3.2 Summarizing legal commodities prices

Table 1: Commodities and Factor Loadings

Factor weights: Mining, Cattle, Agriculture

Mining		Cattle		Agriculture	
Copper	0.7837	Shrimp	0.7361	Bananas	0.6679
Petroleum	0.7585	Meat	0.7089	Coffee	0.6420
Nickel	0.6262	Bananas	0.2886	Palm oil	0.5086
Fish	0.6229	Coal	0.2253	Shrimp	0.3152
Gold	0.5943	Copper	0.1574	Copper	0.2389
Coal	0.5342	Fish	0.1541	Gold	0.2040
Palm oil	0.4426	Nickel	0.1358	Nickel	0.1846
Meat	0.2673	Petroleum	0.0801	Fish	0.1819
Coffee	0.1246	Coffee	-0.0450	Coal	0.0115
Shrimp	0.0806	Palm oil	-0.3162	Meat	-0.1610
Bananas	-0.0347	Gold	-0.4584	Petroleum	-0.3133
Eigenvalue	3.17		1.50		1.30
Variation	28.79%		13.64%		11.84%

Note: This table shows the scoring coefficients of each commodity in each factor in descending order. We call the first factor a mining price index, the second cattle, and the third agriculture. For each factor, we show the list of commodities in order of importance. The bottom lines show the eigenvalue of each factor and the percentage of the total variance explained by each factor. We use data on commodities prices from the IMF and principal component analysis to compute each factor.

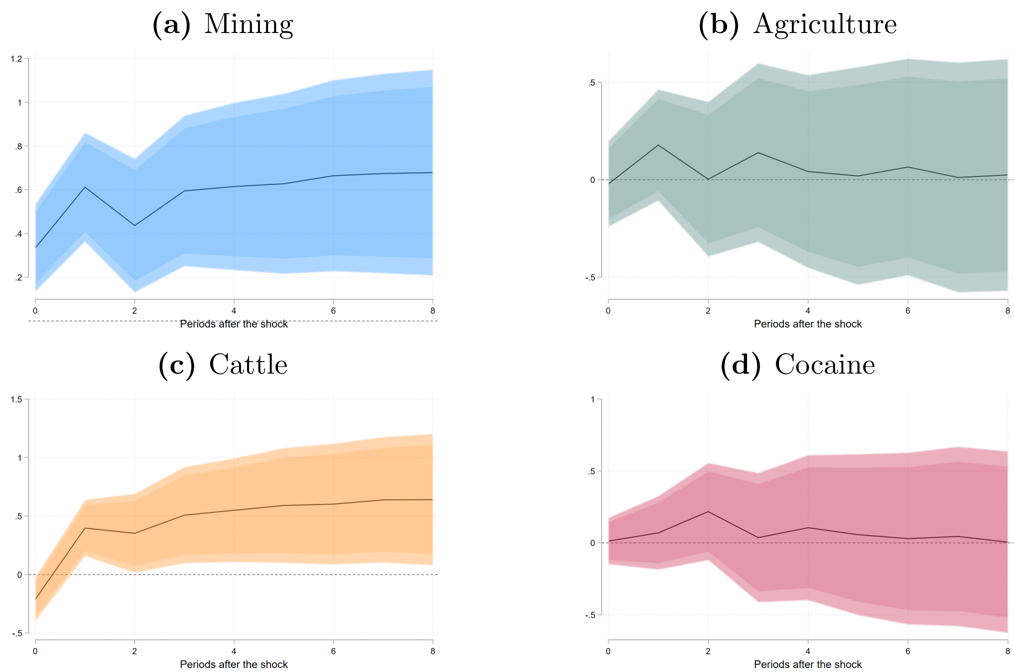
Using principal component analysis and following the Keiser criterion to choose the number of factors, we construct three price indexes that summarize the variation of legal commodities prices.[6] Table 1 shows the weight of each commodity in explaining the factor variation. The first factor (first two columns in the table) mostly summarizes mining prices. We call this factor mining. Similarly, the second factor (columns 3 and 4) contains information about cattle prices since the highest loadings are meat and shrimp. We call it the cattle factor. Finally, the third factor summarizes

[6] The Keiser criterion establishes that the researcher should keep the factors with eigenvalues greater than one.

bananas and coffee prices, which we call the agriculture factor. It is worth noticing that our factors explain over 54% of the total variance of commodities prices.[7]

3.3 Not all commodities are the same

Figure 2: Impulse Response Functions of GDP



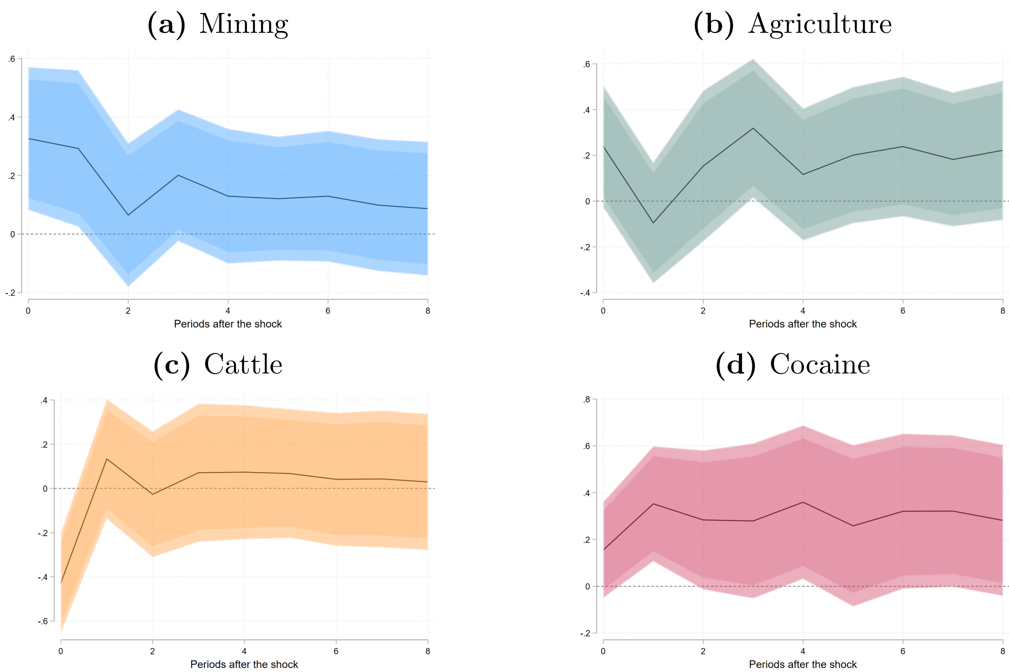
Note: This figure shows the impulse response functions of GDP using equation 4. The horizontal axis shows the number of quarters after the shock, and the vertical axis shows the estimated response. All results are standardized, and we show responses to a one-unit standard deviation shock. Panel (a) shows the effect of mining shocks, panel (b) shows the effects of agriculture, panel (c) shows the effect of cattle, and panel (d) the effect of cocaine. We compute standard errors using a wild bootstrap with 1000 repetitions. We report 90% and 95% confidence intervals.

Figure 2 shows the impulse response functions of GDP to mining, agriculture, cattle, and cocaine prices shocks, respectively (panels (a) to (d)). A one standard deviation shock in mining prices produces a quarter standard deviation increase on impact to GDP, then permanently accumulates to a 2/3 increase (figure 2a). An equivalent shock to cattle prices first decreases GDP by a quarter of a standard deviation, and the effect is then almost comparable in magnitude to the effect of a mining shock (figure 2c).

[7] We use growth rates of standardized prices to construct all indexes. Figure 6 shows the evolution over time of each price index.

In this section, we show that the nature of the commodity price shock matters. The effects on real economic activity differ when considering mining, agriculture, cattle, or cocaine prices. We can summarize our results in two blocks. First, mining and cattle prices present similar responses and agriculture and cocaine prices. In general, shocks to mining and cattle produce increases in aggregate demand and a real exchange rate appreciation. On the contrary, if something, agriculture and cocaine prices shocks increase investment. Also, cocaine price shocks increase employment, reduce wages, and produce a real exchange rate depreciation. On the other hand, agriculture and cocaine price shocks do not produce an effect on GDP (figures 2b and 2d). When we think about domestic GDP components, the direction of the results is similar for consumption and investment (Figures 7 and 8 in the appendix). It is worth highlighting that consumption increases in response to mining shocks, and if something, it decreases in response to agriculture and cocaine shocks. The investment response is positive for all shocks but not statistically significant for agriculture shocks.

Figure 3: Impulse Response Functions of Employment

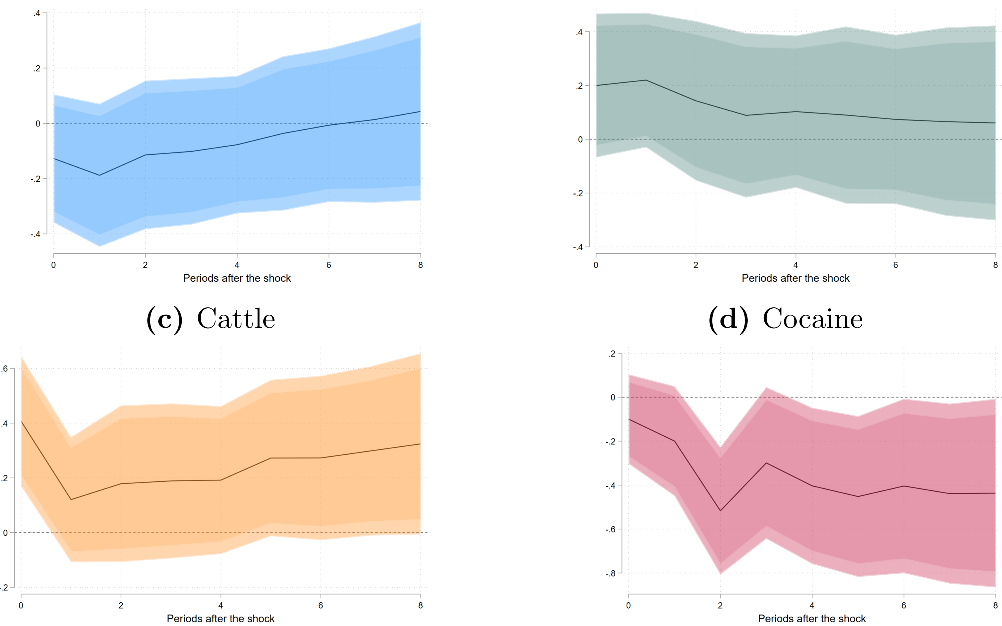


Note: This figure shows the impulse response functions of employment using equation 4. The horizontal axis shows the number of quarters after the shock, and the vertical axis shows the estimated response. All results are standardized, and we show responses to a one-unit standard deviation shock. Panel (a) shows the effect of mining shocks, panel (b) shows the effects of agriculture, panel (c) shows the effect of cattle, and panel (d) the effect of cocaine. We compute standard errors using a wild bootstrap with 1000 repetitions. We report 90% and 95% confidence intervals.

The effects of different commodities prices are also quite different when we study the labor market. Figure 3 shows the impulse response functions to employment. The effect of mining prices is again positive and statistically significant in the first six months after the shock. In response to a one standard deviation mining shock, employment increases 1/3 of a standard deviation (figure 3a). Similarly, employment goes down by a half standard deviation on impact in response to a cattle shock 3c), but then the effect disappears. The response to an agricultural shock lies somewhere between the cattle and the mining shock 3b). This time, the response to a one standard deviation cocaine shock produces a permanent positive response in the employment rate of 0.4 3d).

Figure 4: Impulse Response Functions of Wages

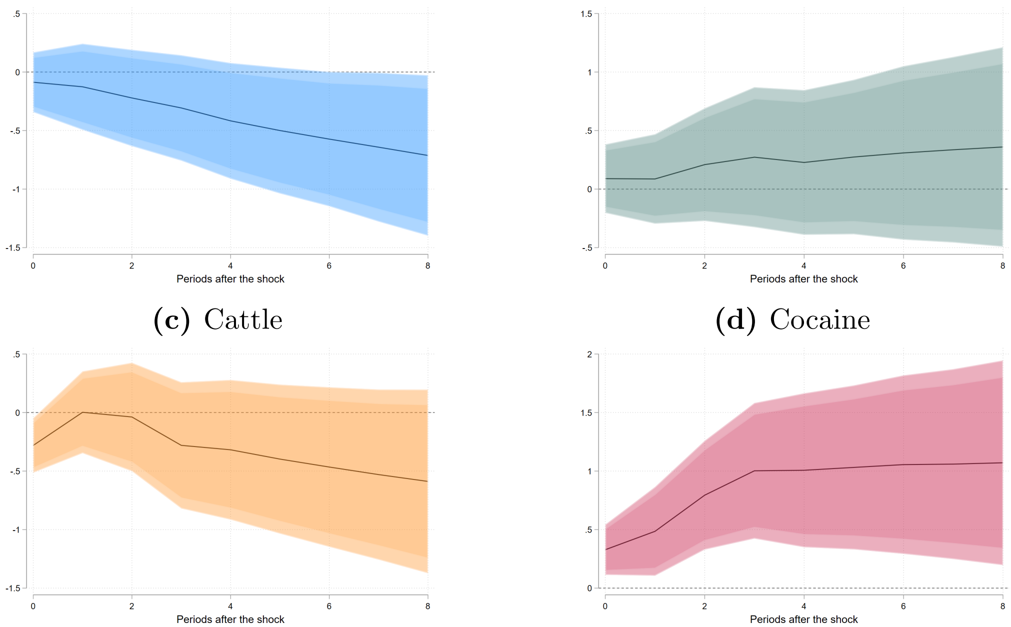
(a) Mining — **(b)** Agriculture — **(c)** Cattle — **(d)** Cocaine



Note: This figure shows the impulse response functions of wages using equation 4. The horizontal axis shows the number of quarters after the shock, and the vertical axis shows the estimated response. All results are standardized, and we show responses to a one-unit standard deviation shock. Panel (a) shows the effect of mining shocks, panel (b) shows the effects of agriculture, panel (c) shows the effect of cattle, and panel (d) the effect of cocaine. We compute standard errors using a wild bootstrap with 1000 repetitions. We report 90% and 95% confidence intervals.

Figure 4 also shows that the differences are particularly striking for wages. The effect of a one standard deviation shock on mining does not produce wage changes (figure 4). However, a one-unit positive shock of agriculture and cattle, respectively, produces a positive and statistically significant increase in wages on impact (figures

Figure 5: Impulse Response Functions of Real exchange rate



(a) Mining **(b)** Agriculture **(c)** Cattle **(d)** Cocaine

Note: This figure shows the impulse response functions of the real exchange rate using equation 4. The horizontal axis shows the number of quarters after the shock, and the vertical axis shows the estimated response. All results are standardized, and we show responses to a one-unit standard deviation shock. Panel (a) shows the effect of mining shocks, panel (b) shows the effects of agriculture, panel (c) shows the effect of cattle, and panel (d) the effect of cocaine. We compute standard errors using a wild bootstrap with 1000 repetitions. We report 90% and 95% confidence intervals.

4b and 4c). Surprisingly, in response to a one standard deviation shock of cocaine prices, wages permanently decline for almost half of a standard deviation.

Finally, when we think about trade, the effects are also different. For instance, figure 5 shows the impulse response functions to the real exchange rate index. By construction, an increase in the real exchange rate represents a real domestic currency depreciation. In other words, when the real exchange rate increases, the Colombian economy becomes cheaper relative to foreign countries. Figures 5a and 5c show that in response to these shocks, the domestic currency appreciates (negative effect). However, a one-standard-deviation cocaine price shock produces a large permanent real exchange rate depreciation: the real exchange rate increases by one standard deviation (figure 5d. Although not statistically significant, an agriculture price shock produces real exchange rate depreciation. We could interpret these as shocks that somehow make the domestic economy more competitive with the rest of the world.[8]

4 Model

In this section, we develop a small open economy model with tradable and non-tradable goods to rationalize empirical findings regarding the different responses of real economic activity to commodities price shocks. This economy trades with the rest of the world using manufacturing goods, also used for investment, and raw commodities: mining, agriculture, and illegal crop. Legal commodities differ in their use of land, capital, and labor. The illegal crop only uses a fixed land factor. The sources of uncertainty in the model are changes to commodities prices. The key characteristic of the model is that the illegal sector uses part of its profits to finance domestic investment, thus affecting the supply of capital. In equilibrium, shocks to cocaine prices change labor supply and wages. Shocks to agriculture and mining play different roles because each sector differs in its labor intensity and land use.

In the model, time is discrete. The sources of uncertainty in the model are changes to commodities prices. An aggregate state s_t vector is governed by a Markov process with transition probability $\pi_s(s'|s)$, where s and s' are elements of the common state space $\mathbf{S}$. We move next to describe households and all sectors of production.

4.1 Households

The representative household comprises many infinitely lived individuals and owns the firms. In every period, the household consumes a composite good $c(s_t)$ of tradable and non-tradable goods, invests in a bond from the international markets $b(s_t)$, and invests $x^{\text{legal}}(s_t)$ in the manufacturing good K. The household supplies capital $K_j(s_t)$ and labor $N_j(s_t)$ to all legal sectors $j = \{A, M, K, NT\}$, that is agriculture A, mining M, manufacturing K, and non-tradables NT. It also supplies a fixed amount of land L to the mining and agriculture sectors. The household takes all prices as given: international interest rate $r(s_t)$, prices of consumption goods $p^j(s_t)$, wages $w(s_t)$, and capital rental rate $R(s_t)$, and price of land p^L.

[8] Figure 9 in the appendix shows that the impact of mining and a cattle shock produces a positive trade balance, and then it is permanently negative. The effect of a cocaine price shock produces a permanent negative trade balance.

To simplify the notation, we suppress the aggregate state s_t in the rest of the text when describing the elements of the model, but all outcomes are a function of this state. The household's recursive problem is

$$V_H(s,b) = \max_{c,b,x} U(c, \sum_j N_j) + \beta \mathbb{E} V_H(s', b') \tag{7}$$

subject to

$$c = \Big(\sum_j \alpha_j^{\frac{1}{\sigma}} c_j^{\frac{\sigma}{\sigma-1}} \Big)^{\frac{1}{1-\sigma}} \tag{8}$$

$$\sum_j p^j c^j + (1+r)b + x^{\text{legal}} = w \sum_j N_j + R \sum_j K_j \; + p^l (L^A + L^M) + b'. \tag{9}$$

4.2 Production

At the beginning of the period, the household and the firms observe international prices and hire all of their factors of production. The only sources of uncertainty in the model are international commodities prices. They follow the an AR(1) process:

$$\log(p^j) = \eta \log(p^j_{t-1}) + \upsilon_{jt}, \tag{10}$$

where $\upsilon_j \sim \mathcal{N}(\mu_j, \sigma_j^2)$. Notice that the household makes the investment decision affecting the current manufacturing good stock before knowing the set of commodities' international prices.

4.2.1 Production of legal commodities: Mining and Agriculture

The representative firm maximizes profits using sector-specific fixed land, manufacturing goods, labor, and constant returns to scale production function. To simplify notation, we will refer in this section to each sector as $j = \{M, A\}$ as follows:

$$\max_{K^J,N^J} P^j Y^j - wN^j - RK^j - P^L L^j \tag{11}$$

subject to

$$Y^j = f(K^j, N^j, L^j) \tag{12}$$

The market clearing condition for legal commodities is given by:

$$Y^j = c^j + NX^j + D^M, \tag{13}$$

where NX^j are net exports of commodities.

4.2.2 Illegal sector: investment and market clearing

We define the illegal sector as an income shock to the economy. All we know about this sector is that a fixed proportion of land is destined for cocaine production. In every period, changes to the international price of cocaine generate resources that affect total investment in the economy, thus changing relative prices of domestic factors of production. Production of cocaine is defined as follows:

$$p^c Q^c = \pi^x + \pi^c, \tag{14}$$

where p^c is the international price of cocaine, Q^c is a fixed supply of cocaine, π^x are the profits used for domestic investment, and π^c are the profits shipped to the rest of the world. This means that total investment in the economy is defined as follows:

$$k' = (1-\delta)k + x \tag{15}$$

$$x = x^{\text{legal}} + \pi^x, \tag{16}$$

where x is total investment in the economy, x^{legal} is the legal investment by households, and π^x is a fraction of cocaine profits destined for the domestic economy. Notice that an illegal shock to investment changes the value of net exports compared to an economy without this illegal sector.

4.2.3 Production of Non-tradables

We start by describing the problem of the non-tradable sector. The representative firm produces a final good using capital and labor to maximize profits. We use the price of non-tradable goods as the numeraire. The firm produces using a constant return-to-scale production function. The problem of the firm is the following:

$$\max_{k^{NT},N^{NT}} Y^{NT} - wN^{NT} - Rk^{NT} \tag{17}$$

subject to

$$Y^{NT} = f(K^{NT}, N^{NT}) \tag{18}$$

The market clearing condition for the non-tradable sector is:

$$Y^{NT} = c^{NT} \tag{19}$$

4.2.4 Production of Manufacturing

Manufacturing goods play the role of intermediate goods, and they are used for investment. The representative firm maximizes profits using mining, agriculture, and labor and a constant returns to scale production function and taking all prices as given:

$$\max_{D^A,D^M,N^M} P^M Y^M - wN^M - P^A D^A - P^M D^M \tag{20}$$

subject to

$$Y^M = f(D^M, D^M, N^M) \tag{21}$$

where D^A and D^M are demand for agriculture and mining. The market clearing condition for manufacturing is given by:

$$Y^M = c^M + NX^M + x^{\text{legal}}, \tag{22}$$

where NX^M are net exports of the manufacturing good.

4.3 Equilibrium and market clearing

The equilibrium is defined as follows. Given initial conditions k_0 and b_0, allocations of land L^A, L^M, and Q^c, a contingent state s, realizations of the shocks in Z_j, and a steady-state bond holdings position $\bar{b}$, an equilibrium is a sequence of allocations—k_{jt}, c_{jt}, b_t, NX_j,$N_{jt}.\pi^c, \pi^x$ —and prices—w, $p_{j,t}, R, r, p^L$—such that all the markets clear for firms and households.

5 Conclusions

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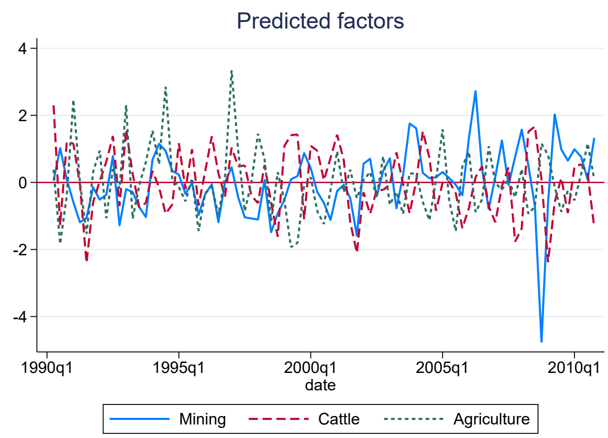
A Appendix: Data

Table 2: Summary statistics: Commodities exports shares

Commodity	Share	Std. Dev
Petroleum oil	39.20	6.58
Coal	15.94	3.71
Coffee	11.95	9.36
Flowers	5.36	1.41
Bananas	3.92	1.86
Ferro-nickel	3.84	1.82
Gold	3.60	2.27
Cane sugar	2.64	1.04
Meat, beef	0.89	0.96
Copper	0.62	0.53
Crustaceans, shrimp	0.59	0.54
Palm oil	0.48	0.32
Fish, tuna	0.28	0.25

Note: The first column of this table shows the list of commodities that explain 90% of Colombia's commodities export between 1990 to 2010. The second Column shows the standard deviation of each of the commodities. Data soruce: Own calculations using data from COMTRADE

Figure 6: Evolution of Mining, Cattle and Agriculture price indexes



Note: This figure shows the evolution of the mining, cattle and agriculture price indexes. The horizontal axis shows the value of the index, and the horizontal axis date. All variables have mean 0 and standard deviation 1. The blue solid line shows the mining factor, the red dashed line the cattle factor, and the green dotted line shows the agriculture factor. We compute each factor using principal component analysis and price indexes of petroleum, coal, coffee, flowers, bananas, gold, cane sugar, copper, shrimp, palm oil, and fish from the IMF commodity outlook.

Table 3: Summary Statistics: Colombian Real Economic Activity

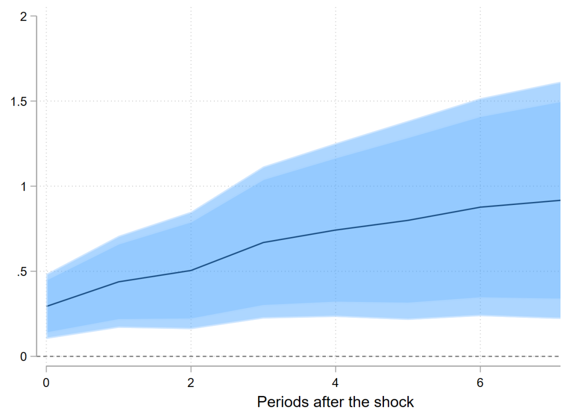
	(2) Mean	(3) Std. Dev	(4) Pctile. 95	(5) Pctile. 5	(6) N
GDP	1075.25	111.06	1269.68	965.55	68
Investment	230.37	61.84	317.27	129.44	68
Consumption	730.76	58.21	829.65	663.19	68
Trade balance to GDP	-0.03	0.03	0.01	-0.07	68
Employment (%)	54.15	2.10	57.78	50.80	68
Wage	2.31	0.88	3.71	0.95	68
Real exchange rate	125.83	17.18	161.09	101.20	68

Note: This table shows summary statistics for the real economic activity variables. Column (1) shows variables names, column (2) shows the mean over the sample period, column (3) standard deviation, column (4) the 95th percentile, column (5) the 5th percentile, and column (6) the number of observations. GDP, investment, and consumption are in Real US dollars of 2010-Q4. Employment shows the employment rate. Wage shows the average hourly wage in Real US dollars of 2010-Q4. Real exchange rate is an index of the real COP US exchange rate using consumer price indexes. Data sources: GDP, consumption, investment, trade balance, wages and employment are from DANE, population, nominal exchange and real exchange rate data are from Haver. We compute all per capita terms and ratios.

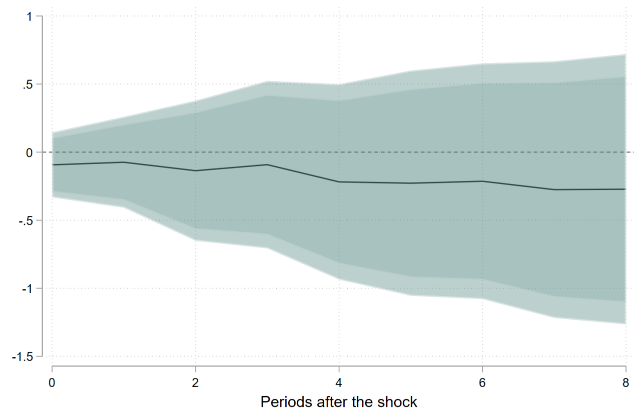
B Appendix: Empirical Results

Figure 7: Impulse Response Functions of Consumption

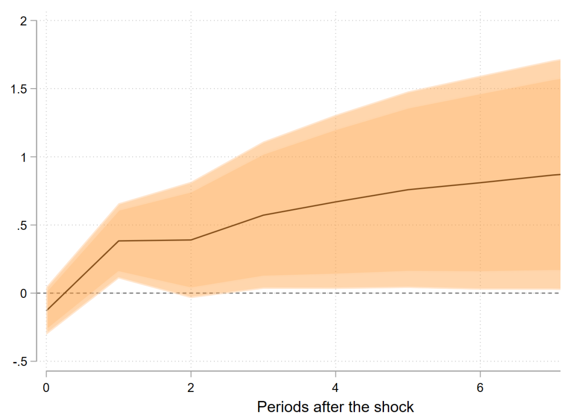
(a) Mining



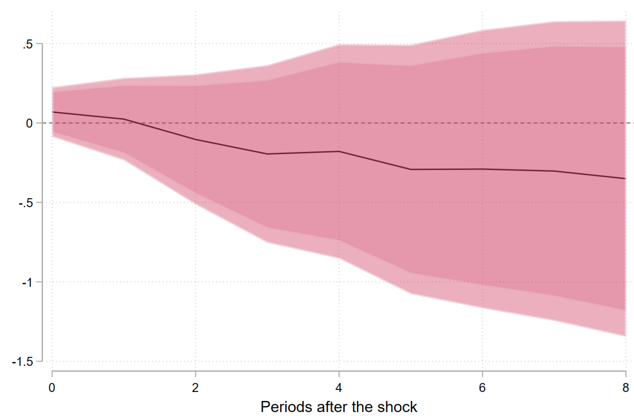
(b) Agriculture



(c) Cattle

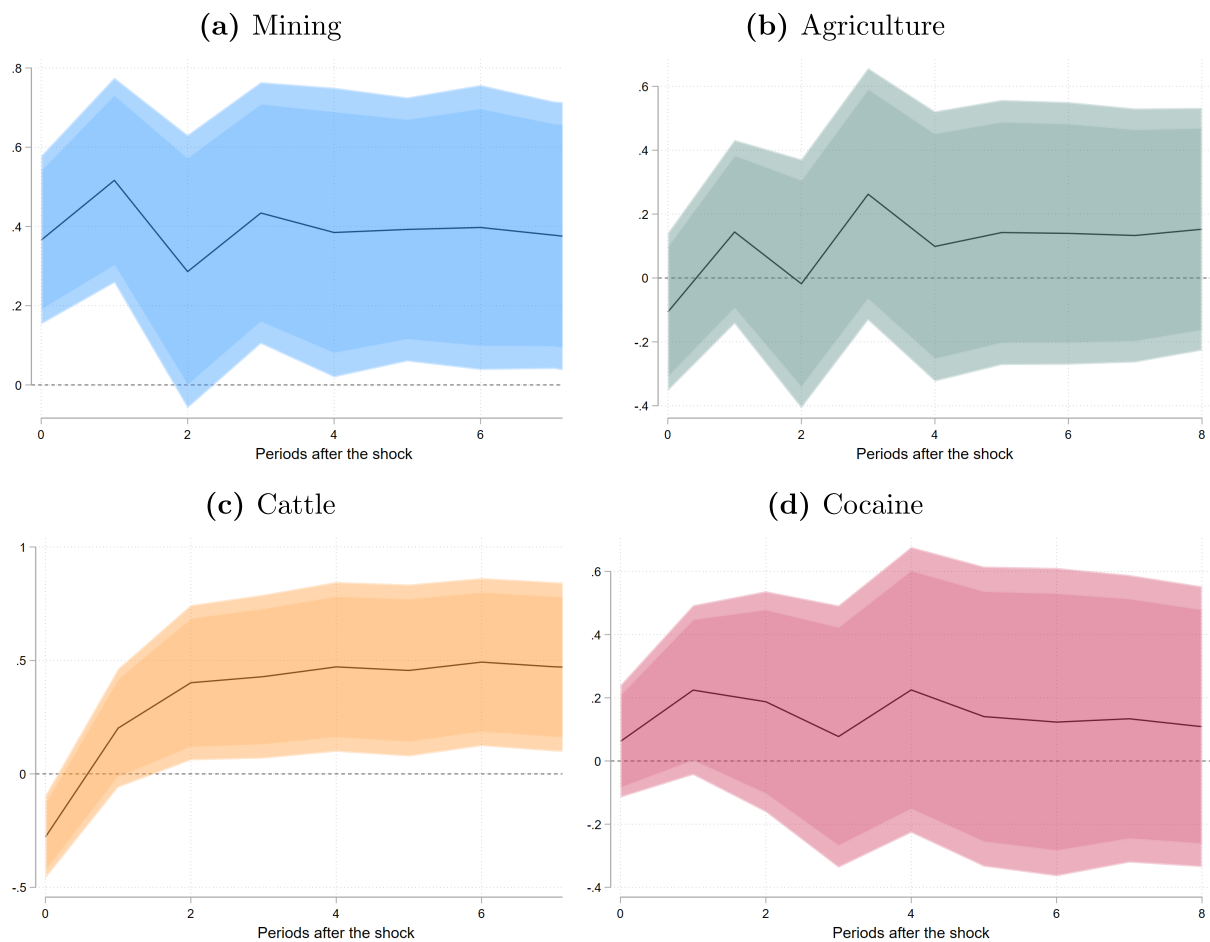


(d) Cocaine



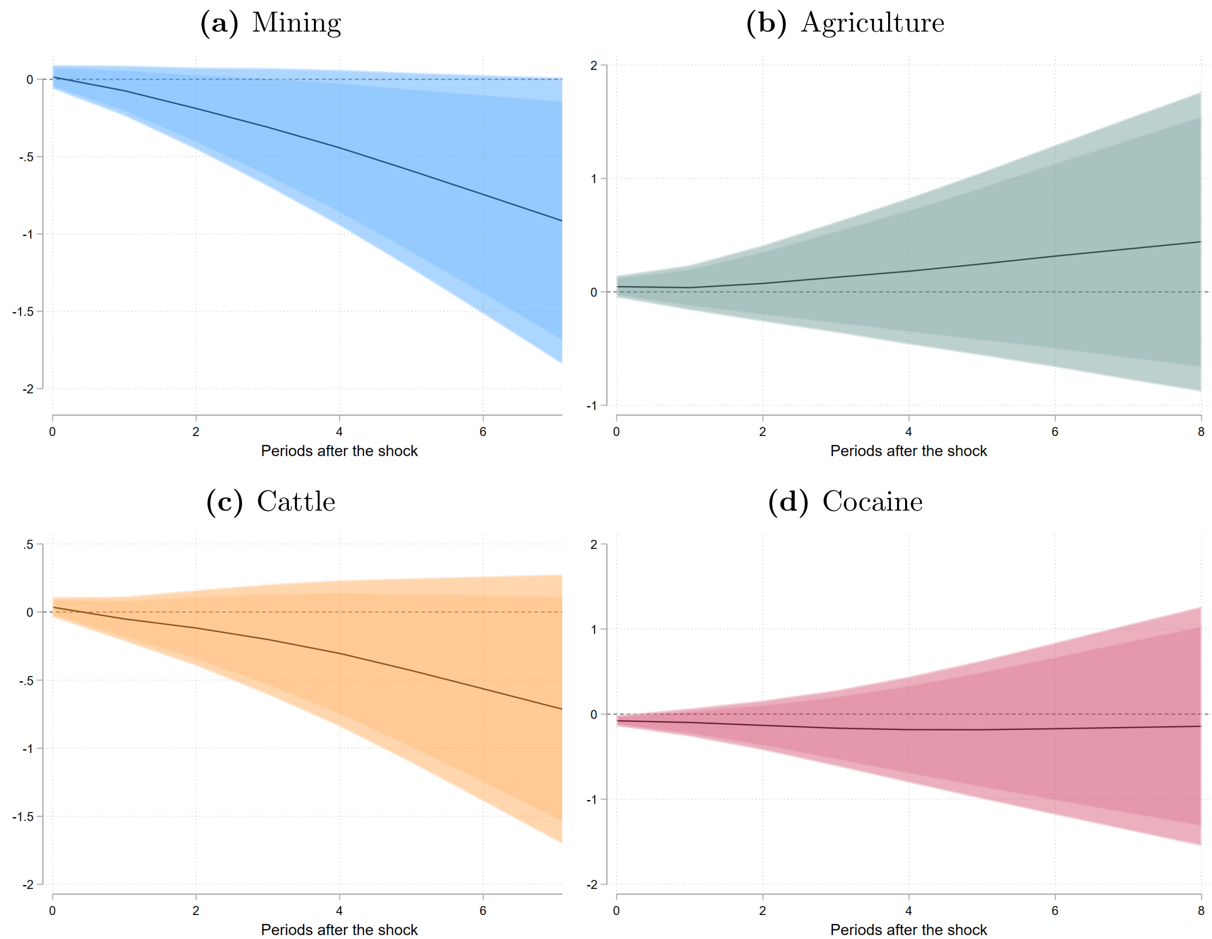
Note: This figure shows the impulse response functions of consumption using equation 4. The horizontal axis shows the number of quarters after the shock, and the vertical axis shows the estimated response. All results are standardized, and we show responses to a one-unit standard deviation shock. Panel (a) shows the effect of mining shocks, panel (b) shows the effects of agriculture, panel (c) shows the effect of cattle, and panel (d) the effect of cocaine. We compute standard errors using a wild bootstrap with 1000 repetitions. We report 90% and 95% confidence intervals.

Figure 8: Impulse Response Functions of Investment



Note: This figure shows the impulse response functions of investment using equation 4. The horizontal axis shows the number of quarters after the shock, and the vertical axis shows the estimated response. All results are standardized, and we show responses to a one-unit standard deviation shock. Panel (a) shows the effect of mining shocks, panel (b) shows the effects of agriculture, panel (c) shows the effect of cattle, and panel (d) the effect of cocaine. We compute standard errors using a wild bootstrap with 1000 repetitions. We report 90% and 95% confidence intervals.

Figure 9: Impulse Response Functions of Trade Balance



Note: This figure shows the impulse response functions of the trade balance using equation 4. The horizontal axis shows the number of quarters after the shock, and the vertical axis shows the estimated response. All results are standardized, and we show responses to a one-unit standard deviation shock. Panel (a) shows the effect of mining shocks, panel (b) shows the effects of agriculture, panel (c) shows the effect of cattle, and panel (d) the effect of cocaine. We compute standard errors using a wild bootstrap with 1000 repetitions. We report 90% and 95% confidence intervals.