Birkbeck Working Papers in Economics & Finance

Birkbeck
UNIVERSITY OF LONDON

School of Economics, Mathematics and Statistics

BWPEF 0906

Drugs and Violence in Colombia: a VECM Analysis

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Abstract

It has been widely argued that the production of illegal drugs, particularly cocaine, has financed guerrilla activity in Colombia. This paper uses quarterly time-series data for Colombia 1994-2005 to examine the interaction between legal agricultural production, illegal agricultural production of drugs and the number of guerrilla attacks. The time series analysis suggests that drug production acts as a weakly exogenous stochastic trend which has a negative effect on legal agricultural production and a positive effect on guerrilla attacks; with a long-run elasticity of attacks to drug production very close to unity.

1 Introduction

Collier and Hoeffler (1998) provoked an extended debate about the roles of 'greed and grievance', economic and political factors, in civil wars. Their paper is part of a large and growing economic literature on civil wars reviewed by Blattman and Miguel (2009), which underscores two economic dimensions to conflict: each side must have both the desire and the ability to fight. The desire may be motivated by economic factors such as acquiring resources; the ability depends on the technology of fighting and the availability of resources,

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which in turn depends on opportunity costs (e.g. what is needed to attract fighters).

Besley and Persson (2008) provide a theoretical model that emphasises the elements of motive, opportunity cost and technology, and present cross-section evidence suggesting higher world market prices of exported, as well as imported commodities, are strong and significant predictors of civil war. Using case studies, Arnson and Zartman (2005) also focus on the ways civil wars are financed, including Colombia. Their work highlights how governments and insurgents have obtained revenue from oil, 'blood diamonds', minerals like coltan in the Democratic Republic of Congo, and the production of illegal drugs such as poppies for opium and heroin in Afghanistan and coca for cocaine in Colombia.

We examine the case of Colombia, which has a long and complicated history of conflict. Not only have combatants included left-wing guerrillas, right-wing paramilitaries, drug traffickers and various governments, but in the last threes decades there has been a substantial production of illegal drugs providing an alternative employment source to legitimate agricultural production. So individuals not only have occupational choices between legal farming, illegal farming of drugs or becoming guerrillas or soldiers, but revenues from drugs can also be used to finance guerrilla attacks. In principle, drug production has an income effect, financing attacks, and a substitution effect, providing an alternative occupation to guerrilla activity. In practice the linkage may be more indirect in Colombia since coca production is not very land or labour intensive, and it occurs in areas outside government control away from the areas of legitimate agricultural production.

Dube and Vargas (2008) use a very detailed Colombian panel of locality data to examine the impact of income shocks on violence. Colombia produces oil and coffee as well as coca, and over the period they consider there were two large income shocks: a drop in the price of coffee and a rise in the price of oil. By comparison of municipalities that grew coffee with those that did not and those that had oil reserves and pipelines with those that did not, they suggest that both income shocks increased violence. The coffee shock by increasing poverty and thus reducing the opportunity cost of becoming a guerrilla, the oil shock by providing resources for increased government counter-insurgency activity.

Unlike their detailed micro-econometric approach, we adopt a macro-econometric approach. While identification of causal influences is more difficult with aggregate data, the results relate more directly to macroeconomic policy issues. The data we examine are quarterly measures of the produc-

tion of legitimate agricultural crops, the production of illegal drugs and the number of attacks by guerillas over the period 1994Q1-2005Q3. All three series appear to be non-stationary and, a priori, there is no presumption that any of the variables are exogenous, so we start from a vector autoregression, VAR, and develop a vector correction model, VECM. Section 2 briefly describes the data and background, section 3 presents the results, and section 4 contains some concluding comments. Although identification issues mean that conclusions must be tentative, it appears that illegal drug production is close to a random walk and acts as a weakly exogenous stochastic trend in two long-run cointegrating relationships that determine guerrilla attacks and agricultural production: illegal drug production increases attacks and reduces legal production.

2   Background and data

It is difficult to determine exactly when the Colombian conflict started. Some argue for the 1930s when a liberal won the Presidency after fifty years of conservative rule in a system incapable of power-sharing or reform. Later, after a long wave of violence, the example and support provided by the Cuban revolution of 1959 led to the creation of the two largest guerrilla groups in the country's history: the ELN (the initials for National Liberation Army in Spanish) in 1964 and FARC (Revolutionary Armed Forces of Colombia) a year later.

In the decades that followed a series of unsuccessful peace attempts allowed guerrilla groups to expand and strengthen. At the same time, illegal drug production shifted from Peru and Bolivia to Colombia thanks to technical improvements in cultivation and to the country's competitive advantages in supplying international markets. Drug trafficking also became a more competitive market with the disruption of the Medellín and Cali Cartels in the early 1990s. Both drug production and guerrilla bases tended to be in relatively inaccessible jungle areas where the government had little control.

A deteriorating security situation followed, with FARC's attacks escalating in the mid 1990s by taking advantage of a relatively ineffective army. Conservatives won the presidential election of 1998 on a platform of peace negotiations, army modernisation and attacks on drug production. Although negotiations failed three years later, the war on drug production gained substantial international backing under the title Plan Colombia, an effort involving crop eradication and social investment in cultivation areas. In 2002 the election was won on a policy of a tougher approach to combating the guer-

rillas which so far has been successful in improving the country's security.

The three series are agricultural GDP, illegal drug production and guerilla attacks, which are graphed below with quarterly data on the top panel and yearly data (to remove seasonality) on the bottom. Agricultural GDP includes crops, livestock, forestry and fishing, and is largely a measure of legal rural activity. Guerrillas recruit from rural areas and most attacks are located in rural areas. Legal agricultural production has a strong seasonal component, is roughly flat till the late 1990s and then grows along with the economy.

There has been considerable debate about whether the output of illegal activities should be included in the national accounts. In the case of Colombia illegal activities are quite large, about 15% of GDP according to Rubio (1995), and drugs are a substantial part of exports. The IMF recommended that the Colombian statistical authority include some measure of the production of illicit crops (latex from poppies, marihuana and coca paste) in the national accounts to ensure consistency between income and production in the agricultural sector. The estimates are based on satellite surveys of the areas cultivated for the production of illicit crops; estimates of local yields and production losses; and estimated market prices paid to farmers for coca paste. The value of downstream production activities, such as processing and distribution of the coca paste, is not included, so this measure is a subset of all illegal production that captures local incomes from illegal activities. Illegal agricultural production also has a strong seasonal component, growing until the late 1990s, then declining with the large eradication campaigns, before flattening out at the end of the period. It averages about a tenth of legal production.

The series for guerrilla attacks was constructed from data in the national police database. It includes attacks by both FARC and the smaller ELN, but not by paramilitaries. Attacks show a trend increase until early 2001, when they fell sharply with the army surge against guerrillas. There is a spike 1996Q3 followed by a drop in the following quarter. The start of the sample is determined by availability of quarterly national accounts data, the end by changes in the classification methodology used in the police database for attacks.

3   Estimates

Using the logarithms of the three series seemed to produce better results, and we denote log drug production as d_t; log of guerilla attacks as a_t; and

log agricultural production as q_t. The usual univariate tests suggested that the three series may be I(1), but these results should be treated with caution since there seem to be clear structural breaks in all three series. It seems more informative to examine the order of integration and cointegration within a multivariate system, which could allow for any co-breaking in the series. However, the rather short time series may cause the multivariate estimates to lack precision. Since none of the variables are, a priori, exogenous, a vector autoregression, VAR, was estimated on the logarithms of the three variables including seasonals and a deterministic trend.

The AIC and SBC information criteria indicated that one lag was adequate (without seasonals the AIC indicated four and the SBC three). The inverse roots of the system were all real at 0.90, 0.37 and 0.18. This is consistent with either all three variables being stationary, or with a single stochastic trend, root of unity, and two cointegrating vectors. The coefficient of its own lag in the illegal production equation was 0.93, with neither of the the other variables being significant, suggesting that the logarithm of illegal production may be close to a random walk. Legal agricultural production was significantly influenced by lagged illegal production, and this was the only apparent Granger causality. The trend was significant in agricultural production though not in the other two equations, and some seasonals were significant in each equation.

Tests for cointegration gave mixed results, with the trace and eigenvalue tests indicating between one and three cointegrating vectors depending on the treatment of the deterministics. However, with unrestricted seasonal intercepts and restricted trends, both tests indicated two cointegrating vectors. This was chosen since it was also the combination selected by the AIC and is consistent with the estimated roots of the system. The system is then

$$\Delta \mathbf{y}_t = \gamma' \mathbf{S}_t + \alpha(\beta \mathbf{y}_{t-1} + \beta^* t) + \varepsilon_t$$

where $\mathbf{y}_t = (a_t, q_t, d_t)'$, $\mathbf{S}_t$ is a vector of four quarterly dummy variables, α is a 3×2 matrix and $[\beta, \beta^*]$ is a 2×4 matrix. With two cointegrating vectors, two just identifying restrictions on each vector of β are required. The fact that drug production appears close to a random walk suggests treating it as a forcing variable, separately determining each of the other two. Using these identifying restrictions the two long-run cointegrating relations are

$$q_t = \quad 16.31 \quad -0.14 \quad d_t \quad +0.002 \quad t \quad +\widehat{z}_{1t}$$
$$\quad\quad\quad\quad\quad (-6.64) \quad\quad\quad (7.58)$$

$$a_t = \quad -6.89 \quad +0.92 \quad d_t \quad +0.0003 \quad t \quad +\widehat{z}_{2t}$$
$$\quad\quad\quad\quad\quad (3.06) \quad\quad\quad (0.07)$$

where $\widehat{z}_{it}$, $i = 1, 2$ are the disequilibrium terms and t ratios are given in parentheses. The long-run elasticity of attacks to drug production is not significantly different from one and the long run elasticity of agricultural production to drugs is significantly negative. There is a significant trend in agricultural production but not in attacks.

The error correction equations, which specify the adjustment to those disequilibrium terms are

$$\Delta a_t = \quad -1.90 \quad z_{1t-1} \quad -0.70 \quad z_{2t-1} \quad +\gamma_1' \mathbf{S}_t \quad +\widehat{\varepsilon}_{1t}$$
$$\quad\quad\quad\quad (-0.95) \quad\quad\quad (-4.59)$$

$$\Delta q_t = \quad -0.75 \quad z_{1t-1} \quad +0.004 \quad z_{2t-1} \quad +\gamma_2' \mathbf{S}_t \quad +\widehat{\varepsilon}_{2t}$$
$$\quad\quad\quad\quad (-4.81) \quad\quad\quad (0.34)$$

$$\Delta d_t = \quad -0.31 \quad z_{1t-1} \quad -0.58 \quad z_{2t-1} \quad +\gamma_3' \mathbf{S}_t \quad +\widehat{\varepsilon}_{3t}$$
$$\quad\quad\quad\quad (-0.56) \quad\quad\quad (-1.38)$$

where $\mathbf{S}_t$ is a vector of four seasonal dummies. There was some indication of heteroskedasticity in the attacks equation and of serial correlation and non-normality in the drugs equation, otherwise the error correction equations seemed well specified. The attack disequilibrium is significant in the attacks equation, the agricultural production disequilibrium in the agricultural output equation and neither in the drugs production equation. This is consistent with drugs production being weakly exogenous. The system was restricted by making the long run effect of d_t on a_t equal unity, $\beta_{13} = -1$; the feedback of the output disequilibrium on attacks zero $\alpha_{11} = 0$; the feedback of the attacks disequilibrium on agricultural output zero, $\alpha_{22} = 0$; and both feedbacks on drug production zero $\alpha_{31} = 0$; $\alpha_{32} = 0$. The LR test statistic for these five restrictions is 2.97. Since this is distributed $\chi^2(5)$ under the null hypothesis, the restrictions can be easily accepted.

The system can be simplified by conditioning on drugs production, dropping insignificant terms and estimating each equation by OLS. Since there are no cross-equation restrictions and the contemporaneous residual correlations are small, all less than 0.3, the system estimates are very similar. With the restrictions the estimates are:

$$\Delta a_t = \begin{array}{ccccc} -5.36 & +0.67 & (d_{t-1} - a_{t-1}) & +0.27 & S_{1t} & +\widehat{\varepsilon}_{1t} \\ (-5.16)) & (5.12) & & (2.89) & & \end{array}$$

$$R^2 = 0.41 \quad SER = 0.27 \quad SC = 0.64 \quad FF = 0.12 \quad N = 0.05 \quad H = 0.06$$

$$q_t = \begin{array}{ccccccccc} 16.32 & -0.13 & d_t & -0.03 & S_{1t} & -0.12 & S_{24t} & +0.002 & t & +\widehat{\varepsilon}_{2t} \\ (94.79) & (-9.42) & & (-3.63) & & (-15.44) & & (9.63) & \end{array}$$

$$R^2 = 0.93 \quad SER = 0.02 \quad SC = 0.51 \quad FF = 0.48 \quad N = 0.93 \quad H = 0.08$$

$$\Delta d_t = \begin{array}{ccccc} -0.08 & +0.60 & \Delta d_{t-4} & +0.16 & S_{12t} & +\widehat{\varepsilon}_{3t} \\ (-2.80) & (4.57) & & (2.92) & & \end{array}$$

$$R^2 = 0.92 \quad SER = 0.06 \quad SC = 0.22 \quad FF = 0.79 \quad N = 0.00 \quad H = 0.53$$

S_{it} is a dummy variable equal to one in quarter i, $S_{ijt} = S_{it} + S_{jt}$. With the estimates and t ratios are also included R^2, standard error of regression, SER, and the p values for tests for fourth order serial correlation, SC; a reset test for functional form, FF; a skewness-kurtosis test for normality, N; and a reset test for heteroskedasticity, H. The drugs equation shows non-normality but otherwise the equations seem well specified at the 5% level. Tests for structural change assuming unknown break points did not indicate any significant breaks.

In the equation for attacks, the long-run unit elasticity restriction is still accepted and the final equation is an error correction process, with a seasonal effect. Agricultural production is a static function of drug production, seasonals and trend. Drug production is an autoregression in Δd_t with seasonals. The term in Δd_{t-4} is needed to remove all serial correlation. Drug production influences agricultural output immediately, but attacks with a lag.

Imposing the restrictions seems to have simplified the model and improved the precision of the estimates, but does not seem to have changed the basic story of a stochastic trend in drug production driving attacks and agricultural output.

4   Conclusion

The estimated equations, whether the unrestricted VECM or the restricted conditional model, suggest that drug production in Colombia over this period was an exogenous stochastic trend. The permanent shocks which drive

this stochastic trend will include any effects not predictable from our data set. These might include changes in the control and organisation of drug production, changes in market prices and government eradication efforts. Drug production had an immediate negative effect on agricultural output, with an elasticity of about -0.13 that suggests a substitution between producing legal and illegal output due to the latter's greater profitability. It is not clear though that this is the full explanation because in Colombia substitution is likely to be affected by the degree of territorial control government forces have and by the location of licit production in a country with an ample supply of arable land.

Drug production has a positive effect on guerrilla attacks with a lag. The long run elasticity of attacks to drug production was close to unity, suggesting a stable long-run ratio of attacks to drug production and supporting the hypothesis that illicit drugs are a critical source of funding for Colombia's illegal armed groups. Once drug producing areas are established it seems they acquire strategic value as resource providers and thus have to be defended by force when attacked by government forces.

Of course, any conclusions can only be tentative because the sample is short, the data is measured with error, the results may be sensitive to specification and identification assumptions and because the parameters are functions of underlying political and economic institutions and may not remain constant outside the estimation sample. Unfortunately, lack of comparable data does not allow us to judge how well the model describes events subsequent to the end of the sample period in 2005. However, were the model is correct; reducing drug production, the policy the Colombian government has followed, would increase agricultural production and reduce guerrilla attacks.

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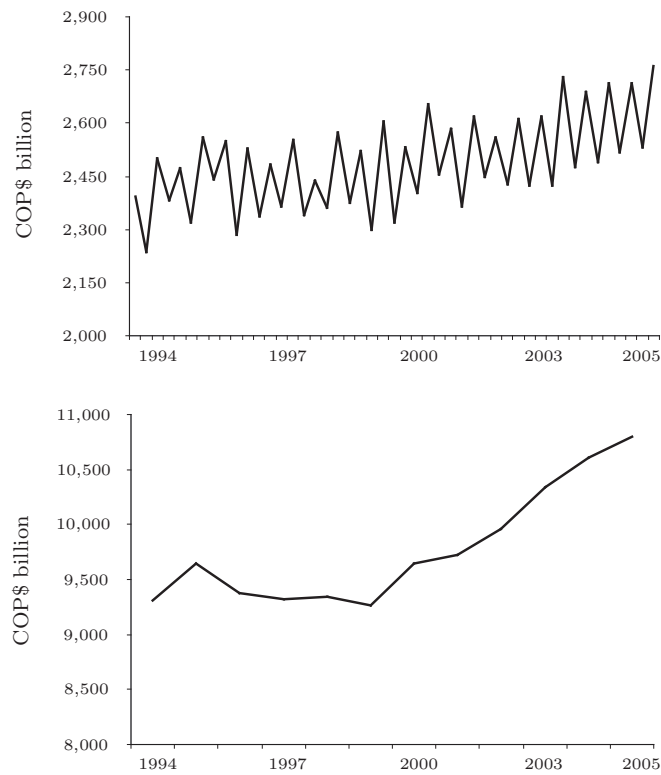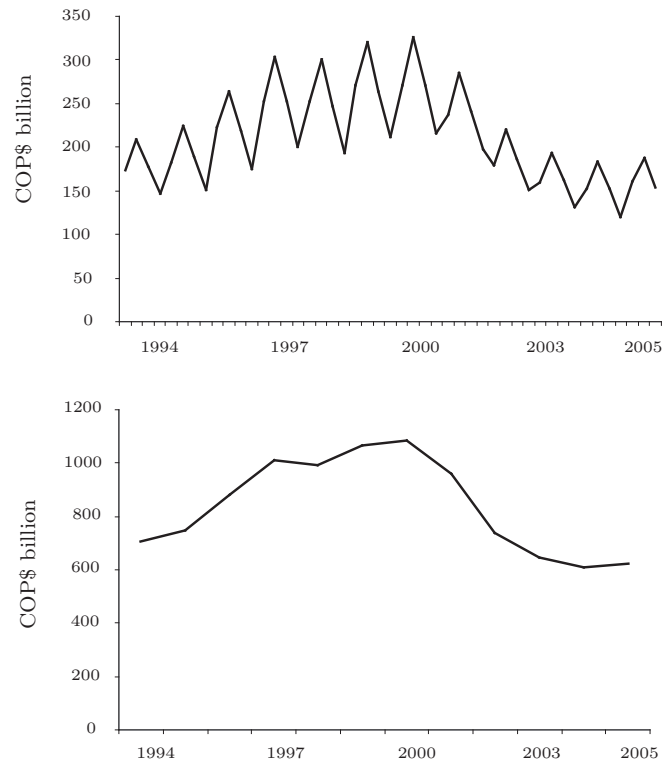Rubio, M. (1995): "Crimen y Crecimiento en Colombia," *Coyuntura Económica*, 25(1).

Figures

Figure 1: Agricultural GDP

Figure 2: Illicit Crops

Figure 3: Guerrilla Attacks