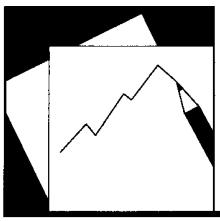
WP/11/182



IMF Working Paper

The Relationship Between Illicit Coca Production and Formal Economic Activity in Peru

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INTERNATIONAL MONETARY FUND

 WP/11/182

IMF Working Paper

Legal Department

The Relationship Between Illicit Coca Production and Formal Economic Activity in Peru

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Authorized for distribution by Ross Leckow

August 2011

Abstract

This paper investigates the relationship between unrecorded economic activity associated with the production of illicit coca and formally recorded economic activity in Peru. It does so by attempting to construct new regional level estimates for coca production and by implementing recently developed panel time series methods that are robust to regional heterogeneity and unobserved regional inter-dependencies. The paper finds that on balance illicit coca production crowds out formal sector production at the regional level, regardless of whether unanticipated changes occur nationally or regionally. However, total output nevertheless increases, since formal sector production is crowded out less than one for one.

JEL Classification Codes: O54, R11, K42, F50, C33.

Keywords: Latin America, Peru, drugs, economic impact, regional economics.

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INTRODUCTION

Peru remains one of the world's largest producers of coca leaves. Available data from the United Nations Office on Drugs and Crime (UNODC) suggests that in 2009 a total of 59,996 hectares were cultivated in Peru to produce coca. This implies the potential to manufacture up to 317 metric tons of cocaine in Peru that year.[2] Official data in Andean countries suggest that the coca and cocaine sector represents only a modest share of total GDP**.** In fact, Peru's national statistics records do not include an estimate for the impact of coca and cocaine production in GDP.

However, illicit cultivation and trafficking of coca leaf products is thought to account for a sizeable portion of the informal,[3] unrecorded sector of the Peruvian economy. A better understanding of the relationship between this largely illegal unrecorded activity and other types of formal and legal informal economic activity may be essential in gauging future trends in Peruvian economic development.

In principle, a number of scenarios are possible for this relationship. For example, it is reasonable to think that resources devoted to the cultivation and trafficking of coca products are being drained from other productive opportunities in the Peruvian economy. In this scenario economic activity associated with the illicit coca sector is expected to decrease economic activity in others sectors of the economy. However, it is also possible that there are economic spillover effects associated with the activities in the illicit coca sector which lead to increases in economic activity in other sectors of the Peruvian economy. In this case activity associated with the illicit coca sector may actually serve to enhance other sectors of the

[2] However, there are also other sources providing data on potential cultivation of coca leaf in Peru (CNC and CADA-CORAH). There are substantial differences among various sources estimates (see Table 1a and 1b in the Appendix).

[3] Despite efforts towards a unified theoretical basis for a definition of the informal economy, there is no unanimity among researchers. In this paper, we use the definition of the "unobserved economy" as proposed in the SNA 2008 to denote the informal economy. The division between legal and illegal unobserved economy is crucial for the discussion of this research. In accordance with the SNA 2008, informal and underground economies are viewed as consisting of both illegal and legal activities. The activities covered by the illegal unobserved economy include among other transactions: tax evasion for income, value added and other taxes, as well as evasion of required social security contributions, noncompliance of certain legal standards for employment, such as minimum wages, maximum hours, safety or health standards, etc., as well as noncompliance of certain administrative procedures, such as completion of required surveys and other statistical reporting forms. The illegal unobserved economy include two types of illegal production: the production of goods and services for wholesale for which distribution or possession is illegal, and production activities that are usually legal but become illegal when carried out by unauthorized producers, such as unlicensed medical practitioners. In our views, the illegal unobserved economy could have spillover effects on the legal unobserved economy as it could interact with the legal informal economy. For further detailed definitions of non-observed economy, see SNA 2008, page 100.

Peruvian economy. The two mechanisms operate in opposite directions and may create opposing effects. Furthermore, the relationships may differ regionally within Peru and may also vary over different time horizons.

An important literature exists on the economic effects of the illicit drug sector on the formal economy. Thoumi (2003) argues for instance, that the drug industry has "depressed the growth of the formal sector of the economy" and that the economy "would do better without drugs than with them." Other scholars such as De Franco and Godoy (1992) write that "cocaine production confers unambiguous benefits to the country." With only a few exceptions, existing studies have typically focused only on income from the drug trade, and have focused on a single country, making comparisons across studies difficult. Moreover, empirical studies have typically relied on national aggregate level data rather than panels of regional data.

The main contribution of this paper is to gain a better understanding of the relationship between illicit coca GDP and non-coca GDP based on empirical evidence. Specifically, we employ panel time series techniques to investigate empirically the extent to which crowding out versus spillover effects occur regionally within Peru, as well as the long run sustainability of illicit coca production.

An improved understanding based on empirical evidence is likely to be valuable to policy makers who must make difficult decisions regarding the best methods for directing economic activity in favor of legal sectors of the Peruvian economy. To our knowledge, this paper represents the first attempt to simultaneously consider national and regional data. To address this relationship, we develop a database of the illegal coca and coca derivatives (gross value added) at a national and regional level spanning the period from 2001 to 2009 at an annual frequency. In this regard, two important limitations need to be borne in mind: (i) the nature of the activity being largely unrecorded makes it difficult to access the relationship between the illicit coca sector and other forms of economic activity in Peru, and (ii) limitations in the availability of coca and coca derivative prices and seizures at the regional level.

The rest of the paper is organized as follows. Section II provides an overview of the expansion of the growth of the coca sector in Peru and discusses the related literature regarding the impact of the drug sector of the economy on other non-coca sectors of formal GDP. Section III presents the challenges and methodological approaches for the empirical analysis, and results are reported in section IV. Conclusions are offered in Section V and all tables and figures are collected in the appendix.

I. BACKGROUND AND RELATED LITERATURE

As we have noted, official data in Andean countries suggest that the coca and cocaine sector represents only a modest share of total income produced in the economy**.** In fact, Peru's national statistics records do not include an estimate for the impact of coca and cocaine

production in GDP. Using UNODC data, we have estimated that the production of illegal coca and cocaine represents the equivalent of 0.9 percent of total GDP in 2009.[4] (See table 3 and figure 7 of the appendix for further details.) By comparison, similar calculations for Bolivia based on UDAPE (2010) data imply that coca leaf represents between 1/8 percent and 1 and 1/4 percent of total GDP, and UNODC sources suggest that illicit coca production represented the equivalent of 21 percent and 14 percent of agricultural output in 2008 and 2009, respectively for Bolivia, as compared to values ranging between 3.6% and 8.25% from 1990 to 2008. Similarly, Colombian DANE (2010) data imply that the share of production of coca and cocaine has ranged between ¾ and 3¾ percent of total GDP from 2000 to 2008, declining toward the end of the period as a result of the coca eradication efforts.[5]

After peaking in 1992, the estimates on Peruvian cultivation of coca leaves sharply declined until bottoming out in 1999. But cultivation has been recovering gradually since then. From 1999 to the present, the officially recorded cultivation of coca leaves in Peru increased 58.84 percent. Despite the strong recovery, estimated hectares of cultivated coca leaves are still below the 1992 peak level. The estimates of coca leaf production in metric tons declined from a peak in early 1992 of about 219,375 metric tons, or more than 70% percent of world production to barely 118,000 metric tons, or more than 37.72 percent of world coca bush cultivation, in 2009.[6] (See figure 5 in the appendix.)

From 2000 to 2007, the increase of coca cultivation and cocaine production in Peru was due to an increase in the demand from new markets primarily in Europe, Asia and Latin America. However, since 2009, the expansion of the Peruvian coca sector can be explained in large part by spillover stemming from the contraction in coca leaf production in neighboring Colombia, which increased the gap between global demand and supply, and increased the Peru's incentive to produce (Diaz and Antezana, 2010). Whereas in the period from 1993 and 1996 Peru cultivated substantially less coca than Colombia, by 2009 Peruvian cultivation of coca was as much as 88 percent the size of Colombia's cultivation.

Over the last 20 years, Peru has undergone an important evolution in the production, processing, distribution, associated logistics, and exportation of the narcotics sector. Peru has evolved from a coca paste producer in 1995 to a cocaine producer in 2009, with an estimated

[4] Note that the estimate of 0.9 is computed as the ratio of illegal coca GDP to national GDP measured in constant 1994 Nuevo Sol (N.S.) units. This estimate is based on data obtained from UNODC and IDEI. Similar data from CNC and CADA-CORAH produce corresponding estimates that range between approximately 0.6 and 1 respectively.

[5] See Diaz and Antezana (2010) for a description of how Colombia's policies in the war against drugs have affected coca production in Peru.

[6] An estimated 59,900 hectares of coca were under cultivation in Peru in 2009, resulting in an estimated supply of 128,000 metric tons of dry coca leaf. According to DEVIDA only 9,000 metric tons are consumed for traditional purposes annually.

317 metric tons of cocaine production.[7] During the period from 2000 to 2009, in response to the Colombian campaign against drug trafficking, coca derivatives production increased significantly in Peru, averaging 317 metric tons[8] in 2009, although this was still below the peak levels of the early 90s. (See Figure 6 in the appendix for further details.) This evolution reflects both an increase in coca leaf cultivation as well as an increase in productivity. In particular, there have been productivity changes in coca leaf cultivation as well as coca paste production, which now has become a unified process. There is a predominance now of micro-production processes for coca paste, which has been extended to the Andean and Amazonian producers that now participate in the drug trafficking chain.

Most coca farmers are micro-entrepreneurs and, according to the experts, regional cocaine producers and traffickers often pay the farmers in advance of the coca harvest. Coca farmers that are unable to secure a buyer for their crop sell their coca in small-scale marketplaces located at river towns in coca growing regions.

The production of coca leaf and cocaine paste in growing regions benefits from a system of established transportation routes protected and controlled by drug trafficking organizations. These regional organizations levy tolls on the producers and transporters of coca, cocaine paste and cocaine HCL. Firms generally process cocaine paste, refining it into HCL in the regional trafficking hubs before transporting it for export. However, more recently, traffickers have begun transporting coca paste directly to the metropolitan Lima area where access to precursor chemicals is significantly easier. Further refinement is then carried out in the Lima area for export.[9]

In Andean countries these illicit sectors do not generate economic activity exclusively in the illegal informal sector, nor do one hundred percent of the funds they generate immediately leave the country in the hands of organized crime. The impact and the transmission channels are complex, but given what is now a comparatively large data set on production and value in these sectors, as well as a growing understanding of how the markets themselves work, we now have a good basis upon which to estimate the impact on recorded GDP.

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[7] Note that this figure is in line with the estimations depicted in Table 1b, when the cocaine extraction efficiency is assumed to be approximately 44 percent and the first data is derived from the UNODC estimates. If the cocaine extraction efficiency is instead assumed to be 72%, the GDP production at the national level will vary accordingly.

[8] According to Garcia y Antezana (2010) from 2000 to 2009 the potential production of cocaine increased 124%.

[9] For a discussion of the historical evolution of the cocaine production and export sector in Peru, please see the 2010 UNODC report “The Globalization of Crime: A Transnational Organized Crime Threat Assessment." See also the National Drug Threat Assessment 2008 (National Drug Intelligence Center, U.S. Department of Justice), and the “The Threat of Narco-Trafficking in the Americas” (UNODC 2008).

The UNODC estimated Peru's potential production of cocaine HCL to be 302 metric tons in 2008. The UNODC has not estimated the potential production for 2009 because it is in the process of revising the conversion factors used in estimating potential production.

Estimates of any illegal activity are highly speculative. Also, the economic effects of the drug sector have been widely debated by economists and sharp differences of opinion exist.[10] Scholars face difficulties when trying to isolate the specific effect of cocaine on the economy and to measure the indirect impact of cocaine on activities such as construction and public services. Thoumi (2003) argues that the effects of the illegal drug industry are complex in that they depend on factors such as which social groups profit from the illegal activity, the structure of the economy, the difficulty or ease of associated money laundering, the way in which illegal assets are laundered, and on government policies and the government's ability to implement the policies.

According to Shams (1992), Peru receives around $800 million a year in foreign revenue from exports of coca base and cocaine. This figure is smaller that reported by Alvarez (1995), according to whom in 1993-94 exports of coca base and cocaine represented between 23 and 40% of legal exports, which amounts to between $0.9 and $1.6 billion. On the other hand, they are similar to the $800 million reported by Nadelman (1989). A smaller estimate appears in Thobani (1994), who estimated Peru's annual net revenue from exports of coca base and cocaine to be approximately $550 million.

II. CHALLENGES AND METHODOLOGICAL SOLUTIONS

Unfortunately, the very nature of the activity being largely unrecorded makes it difficult to access the relationship between the illicit coca sector and other forms of economic activity in Peru. Due to limitations in the availability of coca and coca derivative prices and seizures at the local level, we are only able to produce estimates for national coca production from 2001 to 2009. With very few data points, it is difficult to infer much in terms of causal relationships between the coca sector and other sectors of the economy based on this data alone.

Furthermore, the fact that activity in the coca sector is likely to be highly interdependent with recorded activity in other sectors further confounds one's ability to disentangle causal relationships that are also likely to differ between short and long time horizons. Finally, the

[10] For example, De Franco and Ricardo Godoy (1992) estimated the value of coca/cocaine production in Bolivia in 1987 and 1989 and constructed a CGE model. They conclude that in the short run, the Bolivian economy benefits from the drug industry. Cocaine production increases incomes, demand for goods and services, and, therefore, national production. They conclude that although the growth of the cocaine industry has not produced undesirable cropping patterns at the farm level, it may be making Bolivia, at least at the macroeconomic level, exceedingly dependent on a single commodity, rendering the country vulnerable to the vagaries of the market, nature and international drug policies. The results of their simulations, as well as some of the empirical material presented, suggest that Bolivia may be suffering from a type of Dutch Disease. They also argue that the most important effect of the cocaine industry in Bolivia does not lie in the economic sphere, but rather in eroding the judicial and political system.

fact that the details of the precise mechanisms by which the coca sector interacts with other legal informal and formal sectors is also largely unrecorded only adds to the empirical challenge.

We take a multi-pronged approach to addressing the empirical challenges inherent in this analysis. First, we recognize that with so few data points available at the national level, we must look for information in the form of panel data at the regional level to supplement the national level data. Therefore, to produce a suitable panel of regional level data on coca sector production, we follow a two step procedure. In the first step, we estimate the GDP equivalent of coca and coca derivatives production at the national level annually from 2001-2009 using the same methodology that the National Statistics Institute of Peru (INEI) used to estimate coca and coca derivatives value added for 2007.

Specifically, to construct the GDP[11] equivalents of illegal coca and coca derivatives production, we sum gross value added estimates for four different categories of coca and coca derivatives, namely illegal coca leaf, gross coca paste, washed coca paste, and cocaine. For coca leaf, coca paste and cocaine categories, the gross value added estimates are based on estimated tonnage of production multiplied by price per ton minus costs of intermediate inputs, referred to as consumption. We refer readers to Table 2 of the appendix for more detailed descriptions of the method of data construction for each category. Finally, we note that while the method of construction is reliable, the original data sources are in some cases questionable.

Next, we use IDEI (2009) published estimates of the number of cultivated hectares of illegal and legal coca combined with published estimates of the number of cultivated hectares of the number of tons of illegal and legal coca produced by region in order to calculate the GDP equivalent of illegal and legal coca production by region over the period from 2001 to 2009. In total 14 regions cultivate illegal coca during our sample period, namely Ayacucho, Junín, Cuzco, Huánuco, San Martin, Ucayali, Puno, Loreto, Pasco, La Libertad, Ancash, Amazonas, Cajamarca, Madre de Dios. However, we drop la Libertad, Ancash and Madre de Dios from our analysis due to a lack of data for these regions. This leaves us with a panel of coca production estimates for 11 coca producing regions of Peru.

In using regional level data, we need to recognize that relationships between activities in the coca sector and other economic sectors are likely to differ regionally. This follows from the fact that the composition of economic activity differs regionally with Peru, so that aggregate regional level responses to any shock, whether from the formal sector or the illicit informal sector, is likely to differ in terms of magnitudes and timing. The contrary assumption that all regions respond in an identical fashion to all shocks would seem *a priori* non-plausible. More importantly, if such a restriction were violated, estimation of the mean impulse responses

[11] Note that given the absence of taxes and subsidies, we are able to estimate the GDP equivalent of coca and coca based derivatives based solely on gross value added (GVA) estimates.

across regions would be inconsistent.[12] Accordingly, we use panel time series techniques which allow for and are robust to entirely heterogeneous relationships for different regions. One attractive byproduct of this approach is that we are able to distinguish responses to changes occurring at the regional level versus changes occurring at the national level.

We also recognize that relationships may be different over short time horizons relative to long time horizons. Furthermore, we must account for the fact that activity in the coca sector is highly interdependent with activity in other sectors of the economy, so that neither activity can be treated as exogenous with respect to the other. In short, we must allow for a fully endogenous relationship that ties together the two activities. Toward this end, we employ a mix of panel VAR and panel cointegration methods which allows us to disentangle differing relationships over different time horizons in a framework that allows for and is robust to full endogeneity of the variables.

Furthermore, we recognize that coca production estimates are not perfect, and that the mechanisms by which coca sector activities and other economic activities interact are larger unrecorded. Consequently, as a cross check, we further enhance the robustness of our results by exploring the hypothesized indirect consequences of coca sector activity in different sectors of the formal economy using sectorally disaggregated value added data,[13] which is available reliably at the regional level annually from 2001 through 2009 for 24 regions.

Before turning to results, a few caveats are worth mentioning. On the one hand, the data we use for potential hectares of cultivated illegal coca leaf are all based on data collected by the UNODC and IDEI (2009). On the other hand, the yield table of illegal coca leaf production per region is based on the so called Breakthrough Operation of 2003-2004. However, there is a strong possibility that yields may currently differ from those reported in the study for the 2003-2004 period. Accordingly, these yields may need to be updated in future research. Currently, the UNODC is in the process of revising the conversion factors used in estimating potential production.

Note also that due to data limitations, we are implicitly assuming that only regions producing coca leaf produce coca derivatives. However, in the later years of our sample, coca paste was increasingly transported to the metropolitan Lima area, where access to precursor chemicals is significantly easier, so that further refinement can be carried out in the Lima area for subsequent export. Consequently, it is possible that this leads to overestimation of the coca GDP in some coca leaf producing regions. However, for the purposes of our empirical panel VAR analysis, activity in Lima that affects coca producing regions elsewhere registers as a shock originating at the national level, and is accounted for in this manner.

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[12] See Pesaran and Smith (1995) and Pedroni (2008) among others for econometric discussions regarding the pitfalls of imposing homogeneity in panels for which the true dynamics are heterogeneous.

[13] We assume that formal sector value added data do not include any transaction related to the informal sector illegal coca and derivatives production.

Finally, it is worth considering the details of how coca leaf production estimates are typically transformed into estimates of coca derivatives production. Specifically, cocaine production involves three refining steps, which successively convert the leaves into gross coca paste, washed coca paste, and finally cocaine hydrochloride (HCL, known simply as cocaine for short). The production of paste consists of soaking the leaves in a chemical solution, in order to extract the cocaine alkaloids. In the next step, the coca paste is obtained by removing impurities and concentrating alkaloid contents. In the final stage the coca paste is transformed from a crack-like substance to a soluble powder that can be inhaled. The transformation coefficients for converting coca leaf production estimates into cocaine production estimates at the national level are obtained from the Dirección Antidrogas de la Policía Nacional del Perú (DIRANDRO PNP) and INEI (2009). In principle, transformation coefficients may differ depending on the regional origin of the coca leaf. However, due to data limitations, in this research we assume that the transformation coefficients are similar across regions.

We also assume that intermediate consumption for one hectare of cultivated illegal coca leaf is based on the intermediate consumption for the average yield of one hectare of the VRAE and Alto Huallaga. Again, for simplicity and due to data limitations, we also assume that the coefficients for intermediate consumption/gross production value are similar among coca leaf producing regions for the various stages (gross coca paste, cleaned coca paste and cocaine). Note that we have not pursued an independent analysis of the intermediate consumption for coca leaf and coca derivatives process and take the methodology provided by INEI as correct. Further research might warrant a sensitivity analysis to evaluate the impact on illicit coca production taking into account modern versus traditional methods of coca and coca derivatives production.

Note also that for each year of the sample, we take the regional coca leaf price to be same as the national average coca leaf price for that year. Coca derivatives prices are also not available at the regional level. Unless otherwise indicated we use national prices as depicted in table 12. We experimented using both average period and end of period prices for the CPI index, but found that it made only negligible differences in the national estimates, as reflected in the comparisons between table 3 and table 13. The exchange rate and price indices which we use are obtained from the database of the Central Bank of Peru. The average prices for coca paste and cocaine hydrochloride are all obtained from UNODC sources. By contrast, the cleaned coca paste prices have been estimated.

In principle one might imagine doing an analysis to investigate the sensitivity of coca GDP estimates to different regional price estimates. However, in the absence of reliable price data at the regional level, any such analysis would need to be based on arbitrary numerical values, so that the results would not be of limited relevance. Note furthermore that while coca leaf prices are available for a limited number of regions, the price of coca leaf is miniscule

compared to the price of at other stages of production, so that variations in coca leaf price are unlikely to have much impact on estimates for total coca based GDP by region.[14]

III. RESULTS

A. Long run cointegration analysis

The first set of results involves simply checking the direct long run relationship between estimated coca production and other economic activity. Toward this end, we employ cointegration methods which estimate the average lung run relationship between regional coca production and formal sector production in a way that is robust to heterogeneity among regions and endogeneity of the relationship. Initially, we do this using two different sets of assumptions regarding the distribution of national hectares of coca leaf production among Peruvian regions. In the first approach, we use UNODC averages of coca leaf production ratios that were assigned to each region in 2008 through 2009 and interpolated based on these averages over the remainder of our sample, from 2001 to 2007.[15] In the second approach we use the IDEI estimates combined with published estimates of the number of tons of illegal and legal coca produced by region to directly compute regional coca leaf production by region without the need to interpolate.

Not surprisingly, after confirming the presence of unit roots for all variables using panel unit root techniques, we find evidence in favor of a long run cointegrating relationship using both approaches, although the evidence is stronger in the latter case. These results indicate that a long run causal relationship exists among the two variables, but do not indicate the direction of causality. Furthermore, as evidence of a stable long run relationship, the finding of cointegration between illicit coca and formal sector GDP reveals that the levels of illicit coca activity were sustainable historically during our sample period. In the absence of any dramatic future structural changes to the relationship, this finding points to the likely continued sustainability of these levels of production in future periods.

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[14] ENACO, S.A., handles the processing of incomplete and outdated information such as the registration of farmers who produce coca for legal trade. We assume that the intermediate consumption for one hectare of cultivated legal coca leaf is based on the intermediate consumption of one hectare average yield of Convencion and Lares. Legal coca leaf prices are estimated based on FONAFE information. Data on seizures of illicit coca leaf, cocaine and of gross and washed coca paste are not available at the regional level. For simplicity, we have taken coca leaf and coca derivatives seizures per region to be proportional the national estimates.

[15] The estimates of hectares of cultivated coca leaf do not differ substantially between the first and second approach in the most regions for coca leaf production. Rather, the differences tend to be in regions that are relatively less important for coca leaf production. Figures 1a, 1b and 1c in the annex depict some of the differences in the median results depending on whether one uses the first approach or the second approach. We believe the coca production series based on the IDEI estimates are more credible to the extent that these are based on the estimates of local experts. Nevertheless, it is widely believed that a more consistent and transparent methodology to estimate illegal tonnage of cultivated coca leaf at a regional level is overdue.

Next, a separate test for the direction of long run causality in a cointegrated panel confirms that in both cases changes in the formal sector activity cause changes in the coca sector, at a statistical p-value of between 2% and less than 1% depending on which data approach is used. Tests for the reverse direction of long run causality, such that changes in the coca sector cause changes in the formal sector were more varied depending on which data specification was used, ranging from a statistical p-value of 9% in the former case to 16% in the latter case.[16]

These differing results for the direction of causality illustrate the importance of further investigating which set of assumptions represents the most appropriate method of inference regarding the distribution of cultivated hectares and tons of coca leaf production among regions. Accordingly, it will be valuable to coordinate best practices among the different institutions which provide estimates of local coca cultivation for Peru.

Given that we only have nine annual observations per region, it is not surprising in general that power is low for the long run causality test running from illegal coca production to GDP, and that the results are marginal. The next step in our analysis is therefore to turn toward quantifying the short run causal relationship by means of our dynamic VAR analysis for the panel.[17]

B. Dynamic panel VAR analysis for coca production

Our panel VAR analysis explicitly takes into account the regional heterogeneity in the dynamic relationship between activities in the coca sector and other sectors of the economy. As is standard in VAR analysis, we convert our dynamic estimates into the equivalent response over time of the observable variables to unobserved shocks to the economy originating in either the coca sector or other sectors of the economy. An important byproduct of the panel framework is that we are able to distinguish the regional response of the observable variables to shocks originating at the regional level versus shocks originating at the national level.

Notice that in this approach we are treating the interdependencies as reflected by heterogeneous region specific responses to common aggregate shocks. The very limited amount of data renders it infeasible to also model all of the direct pair-wise interactions that are also likely to occur across regions. To give an example, imagine if we intend to capture the possible effects of each region on other regions. Even with only up to one lag in the timing of these effects, we would require 11x11x2=242 additional coefficient estimates in a

[16] For details on the panel cointegration methodologies for panels, see Pedroni (1999, 2001, and 2004) and Canning and Pedroni (2008), and for the panel unit root methodology see Im, Pesaran and Shin (2003). Detailed numerical results for these various tests are available upon request as a technical appendix.

[17] For the panel VAR analysis we experimented with both data specifications. The results were generally statistically somewhat more significant for the former approach, but given that the more conservative latter approach also resulted in statistically significant results for the short run dynamics, we report only the results for the latter approach in the next section.

panel VAR with 11 regions and 2 variables, which of course is not feasible. In principle one might imagine conducting a spatial econometric analysis to further uncover the degree of spatial dependence among regions. However, with the relatively small dimensionality of our panel, the spatial analysis would by necessity be restricted to contemporaneous dependencies, without the ability to account for dependencies over time. In short, it is not possible with the amount of data at our disposal to concurrently allow for general forms of both temporal and spatial dependencies beyond a simple common dependence structure.

In fact, given that we have a very short panel, we have included only one lag in the VAR specification. The VAR is estimated in log differences, while the corresponding impulse responses are accumulated for the log level responses. Accordingly, the typical VAR specification for the bivariate versions of our panel takes the form:

$$\Delta y_{it} = \alpha_{1,i} + \theta_{11,i}\Delta y_{it-1} + \theta_{12,i}\Delta x_{it-1} + \mu_{1,it}$$

$$\Delta x_{it} = \alpha_{2,i} + \theta_{21,i}\Delta y_{it-1} + \theta_{22,i}\Delta x_{it-1} + \mu_{2,it}$$

Where y_{it} is for example the natural log of regional formal sector GDP and x_{it} is for example the natural log of illegal regional coca production.[18]

The results are depicted in figures 1a, 1b, 1c, and 1d. Of greatest interest are the two diagrams in the lower left and the two diagrams in the upper right. The diagrams on the lower left depict the response of regional formal sector GDP over time to an unexpected positive shock to illegal coca production. The blue line represents the median response among regions, while the green and black lines represent the confidence intervals which reflect the 75^{th} and 25^{th} percentile responses among regions respectively. Specifically, we see that the median response of regional formal sector GDP to coca shocks originating both at the local regional level and the national level are negative. Accordingly, illicit coca production is seen to crowd out formal sector production as reflected in the median regional GDP responses over a two year horizon in all the specifications.

Notice however that while the coefficient value at the two year response is negative, in virtually all cases it is less than one in absolute value. This implies that although illicit coca production crowds out formal sector economic activity, the extent to which it is crowded out is less than one-for-one. The implication is that illicit coca activity must also have some

[18] Being a reduced form VAR, the specification is relatively unrestricted. One implicit restriction comes from orthogonalizing the shocks by means of a reduced form Cholesky triangularization. This implies that while formal sector activity is permitted to have a contemporaneous impact on illicit coca sector production, illicit coca production does not have a contemporaneous effect on legal sector production. The timing on all other transmission channels between the two sectors are left unrestricted. Future work may wish to consider other more structural methods for orthogonalization. Note also, that given the relatively weak cointegration results, we have conservatively estimated the VAR in differences, without imposing cointegration, and then accumulated the impulse responses to see the effects of the shocks on the levels of the variables. See Pedroni (2008) for details on the identification and computation of the impulse response form and the decomposition of shocks into regional versus national in panels.

spillover effects on formal sector GDP. The net effect is that total economic activity, defined as the sum of illicit coca based activity plus formal legal sector activity increases in response to a positive coca shock, despite the fact that illicit coca production does crowd out some formal legal sector production. This finding is not surprising in light of the extent to which economic activity in the informal and formal sectors are intricately linked in most economies.

Another important aspect of our results is that they also reveal considerable heterogeneity across regions, such that the 25% quantile regional responses of formal sector GDP to unanticipated regional shocks to coca production range to as large as -3.0% when we consider the diversity across all regions.

Furthermore, among the different specifications that we explored, figures 1a through 1c of the appendix represent specifications 1 through 3. Among these, figure 1a, based on UNODC ratios, shows the largest median regional formal sector GDP response to unanticipated regional shocks to illicit coca production at -1.75% after two years, while figure 1b based on IDEI ratios shows the smallest median responses for the same shocks, at -0.1%.

In our robustness check based on the estimates of this study, figure 1c, indicates that by the beginning of the second year following a one standard deviation shock to illegal regional coca production, formal GDP in the same region typically falls by 0.25%. Specifically, from the diagram in the third row, second column, we see that the median one standard deviation shock to regional illegal coca production represents roughly a 42% initial first year increase in illegal coca production, which eventually dampens to a 31% net annual increase by the fifth year. Consequently, to give a numerical example based on figure 1c, consider the 2009 estimate for illegal coca production in the region of Ayacucho, at roughly 123 million soles. If we imagine an unanticipated increase in Ayacucho's illegal coca production by 42%, or roughly 51.5 million Soles, then this is in turn leads to a fall in Ayacucho's formal sector GDP by 0.0025%, or roughly 4.7 million Soles. If we instead use the region of Cusco with an estimated 112 million Soles of illegal coca production as an illustration, then a similar unanticipated increase in Cusco's illegal coca production by 42%, or roughly 47 million Soles, would lead to a fall in Cusco's formal sector GDP by 0.0025%, or roughly 11.6 million Soles. Consequently, we see that illegal coca production crowds out formal sector production, but by less than one for one, so that total illegal informal plus formal sector production has increased. Regardless of the size of these effects, we should note furthermore that the variance decompositions indicate that the vast majority of the variation of formal sector economic activity is due to shocks originating in the formal sector, with the illicit coca sector explaining very little of the variation. This is consistent with the fact that the illicit coca sector is very small relative to the formal sector.

Next, consider the implication of the figure 1c diagram in the first row of the second column. Here we are considering the opposite causal relationship, namely the response of illegal regional coca production to an unanticipated shock in formal sector GDP. In this case, we see that an unanticipated shock to regional GDP leads to an increase in illegal coca production, initially on the order of 20% and peaking at a little over 30% by the beginning of the second year. Again, using Ayacucho and Cusco as examples, if we have an unanticipated one

standard deviation, or 3%, shock to GDP in Cusco, equal to roughly 140 million Soles, then this leads initially to a roughly 22 million increase in illegal coca production in Cusco. A similar 3% shock to GDP in Ayacucho, equal to roughly 55.9 million Soles, leads initially to a roughly 36.9 million Soles increase in illegal coca production in Ayacucho. By contrast, as we see in the diagram of the second row in the second column, when the shock to GDP originates at the national level, the regional response of illegal coca production is mixed, with some regions decreasing production while others increase production so that the median regional response is slightly negative, but not statistically different from zero.

As a cross check, we also repeat this exercise using the nine regions for which we have estimates of legal coca production. The results are depicted in figure 2. Here we see that while shocks to GDP originating at national level help to stimulate legal coca production, shocks to legal coca production have relatively small and statistically insignificant effects on formal sector GDP. In contrast to illegal coca production, which crowds out formal sector GDP, legal coca production does not appear to significantly crowd out formal sector GDP at the regional level.

Finally, we also repeat the exercise for illicit coca with an additional control variable, namely regional government investment, which we refer to as specification 4. Government investment is a potentially important for our analysis, because investment in public goods such as infrastructure, health and schooling may change the relationship between illicit coca production and legal economic activity. The precise relationships are likely to be complex and region specific, and are beyond the scope of this study. But it is not difficult to imagine that an increase in public goods provision might decrease the incentive for illicit coca leaf production at a microeconomic level.

Accordingly, we reran the reduced form panel VAR as a three variable system with the following ordering of the variables, formal sector GDP, government investment, and estimated illicit coca production.[19] The results are displayed in figure 1d. As usual, the key results appear among the charts in the lower left hand corner. Here we see that after controlling for government investment, shocks to illicit coca production initially have a similar negative median effect on formal sector GDP, but after three years the effect becomes positive, and then eventually goes to zero.

C. Dynamic panel VAR analysis of observable proxies for coca sector activities

Next, as a further cross check of our general findings we explore the indirect consequences of illegal coca sector activity in different sectors of the formal economy using sectorally

[19] We also considered using mining output as a control variable, since mining represents an important export sector for Peru. However, significant mining and coca production only overlap in 3 regions, which is insufficient to use mining as a viable control. Furthermore, since mining is included in formal sector gross value added, unanticipated shocks to mining are captured by what we call shocks to formal sector GDP. The same is not true for government investment, which is not included in estimates of regional gross value added.

disaggregated GDP data and banking sector data. While this approach requires us to conjecture about the likely channels by which illegal coca production impacts other sectors of the economy, the advantage of this approach as a cross-check to our primary findings is that it does not rely on our estimates of illegal coca production. This also allows us to extend the analysis to all 24 regions of Peru, thereby increasing the sample size substantially.

The first such approach is based on data from the banking sector. Specifically, we hypothesize that illegal coca production, most of which is exported internationally, disproportionately impacts the quantity of Peruvian bank deposits denominated in foreign currency relative to deposits denominated in domestic currency. By contrast, we conjecture that relatively little of the proceeds from the international coca based drug trade is deposited in the form of domestic Soles. While we recognize that other activities also impact the quantity of internationally denominated deposits, this reasoning leads us to take the relative interaction between domestically and internationally denominated deposits in Peruvian banks as a rough proxy for the extent of formal GDP activity relative to illegal informal coca based activity.

The results of this analysis are depicted in figure 3. Again, the most interesting results appear in the two diagrams on the lower left and the two on the upper right. The diagrams on the lower left indicate that a shock to the quantity of international denominated deposits, both at the regional and national levels, leads to a decrease in the quantity of domestic deposits regionally. To the extent that our conjecture regarding the proxy nature of these deposits is correct, these results are consistent with our other findings that illegal coca production crowds out formal sector GDP. Similarly, and again subject to our conjectures regarding the proxy nature of deposits, the results in the upper right hand diagrams are also consistent with our previous results, in that they indicate that shocks to formal sector GDP stimulate illegal coca based activities at the regional level.[20] Needless to say, these results are simply intended as a rough cross check of our primary results. To be taken more seriously at face value, the results would likely benefit from further study, since the analysis of the impact of illicit coca production on bank deposits could be capturing a spurious relationship, as it does not take into account other elements that affect the degree of deposit dollarization in the economy. For example, the evolution of dollarization in Peru likely also reflects other factors of a macroeconomic magnitude and the associated expectations.[21] One future research option

[20] However, one idea put forward in the literature such as Melvin and Ladman (1991) and Melvin and Peiers (1996), is that inflow of dollars from illicit coca and cocaine trade contributed to the dollarization in Latin America. For example, Melvin and Ladman (1991) model the relationship between dollarization and coca production in Bolivia and show that the seasonality of the coca harvest and cocaine production are likely to be a relevant cause for the dollar-denominated loans in the major-coca producing region of Boliva, the Chapare. They concluded that the illicit trade of coca, supplying an important quantity of dollars to the economy, contributes to the dollarization process in Bolivia. Kutan and Cespedes (2006) examined how socio-political factors affect bank spreads and deposits in Bolivia. Their results suggest that violence-related events associated with zero coca policy caused higher spreads and lower deposits. On the other hand, the progress in eradication was associated with lower bank spreads, indicating a decline in the cost of intermediation.

[21] See Garcia-Escribano (2011).

could be to remove some mining regions and to analyze other activities generating income in foreign currency such as tourism in regions such as Cuzco.

The second proxy based approach relies on sectoral level regional GDP data. For this approach, we hypothesize that coca cultivation largely crowds out other forms of agriculture in Peru at the regional level, and that demand for electricity is driven by all forms legal informal, and formal economic activity, but that coca production itself does not employ much electricity.[22] With this conjecture, negative shocks to agricultural production can be interpreted as reflecting, in part, positive shocks to coca production. Furthermore, the response of electricity reflects increases in demand stemming from the subsequent change in all other economic activity. This approach allows us to capture the net effect of the two different channels by which coca production may impact other economic activity, namely by crowding out other forms of production, but also possibly by inducing spillover effects, in the formal and legal informal sectors of the economy. Consequently, by this analysis we see the impact in both recorded formal economic activity and unrecorded informal economic activity. Of course, one limitation to this approach is that it does not take into account the fact that demand for electricity in some major electricity producing regions, such as Junin, likely derives not just locally, but also from other regions within Peru. Again, we offer these results simply as a suggestive cross check of our primary results, and acknowledge that further analysis is necessary if one is to take the quantitative results at face value.

In any event, the results of this analysis are depicted in figure 4. As usual, the most interesting results are in the two diagrams in the lower left and the two diagrams in the upper right of the figure. For example the diagrams on the lower left show shocks to agriculture at the regional and national levels have very small and statistically insignificant effects on electricity. If our conjecture regarding the proxy nature of these shocks is correct, then we see that now that we have accounted for total demand created by both the formal and illegal informal sectors, the net impact of illegal coca production crowds out formal sector GDP activity, but at the same time has a spillover effect on legal informal and formal sector activity, which leads some regions to experience a net positive effect while others experience a net negative effect, with the median regional response being on balance close to zero.

IV. CONCLUDING REMARKS

The findings in this study are subject to several caveats. The first is that estimation of illicit coca production GDP is difficult and imprecise. Furthermore, due to limitations in available

[22] While this analysis is admittedly simplistic, we introduce it here merely as an additional cross check. For example, one important caveat could be that unanticipated weather conditions impact non-coca agricultural production. In this case a negative shock to non-coca agriculture does not necessarily identify a positive shock to coca production. Nevertheless, there is also a vast literature that addresses the idea that in many cases coca production crowds out non-coca agriculture, so that at least some of these shocks to non-coca agriculture are likely to be associated with shocks to coca production. See for example Rodriguez (1965), Tammen (1991), Alvarez (1992), Rojas (2002), Doerr (2003), Moreno et al. (2003), Ball et al. (2006), Mejia and Posada (2008), and Torres (2001) for discussions on the relationship of non-coca agricultural production to coca production.

price data, even these estimates are not possible for long periods of time. We have exploited dynamic heterogeneous panel methods to compensate for the short time periods, but even these methods are subject to imprecision with such small amounts of data. We have conducted numerous robustness checks by using different raw estimates of illicit coca production in our VAR analysis, and by investigating the use of additional control variables. We have also hedged against the short and imprecise estimates of illegal coca production GDP by conducting a parallel analysis using a larger set of sectoral GDP and banking data. But as an approach to cross-validating our results based on the illicit coca production estimates, this requires us to conjecture on the nature of the interaction between coca production and the observed formal sector GDP and banking data.

These caveats notwithstanding, we believe the study makes considerable progress toward a better empirical understanding and validation of the relationship between illegal coca production and formal and informal sector economic activities at the regional level in Peru. More specifically, the empirical analysis in this study supports the idea that on balance illicit coca production tends to crowd out formal sector production at the regional level, but that total production and income nevertheless increase, since the rate at which formal sector production is crowded out is typically less than one for one. When we control for government investment, we confirm a negative effect on formal production over a three year period. However consistent with the hypothesis that there are opposing effects, following a three year period we find that illicit coca production also induces higher formal sector production, although this effect dies out over time.

While it would be interesting to provide a cross-sectional analysis on how Peru compares to other countries in the region, the analysis is not plausible due to the lack of data at this point.

The empirical methodologies that we have exploited here are well suited to make the best of situations in which direct and reliable time series are not always available. Needless to say, even with these techniques, improvements in basic data collection can lead to substantial improvements in inference. Given the importance of the relationship between illegal informal sector activities and formal sector GDP for policy makers at the regional level, we believe it will be important for governments of countries with significant illegal and legal informal economic sectors to continue to invest in the collection of more reliable data estimates. For Peru, the most important areas for improvement include collection of coca and coca derivative production quantity estimates as well as cost and price estimates, as well as data on seizures, all at the level of disaggregation associated with the Peruvian political regions, so that these data can be better matched with other economic data that is collected at the regional level.

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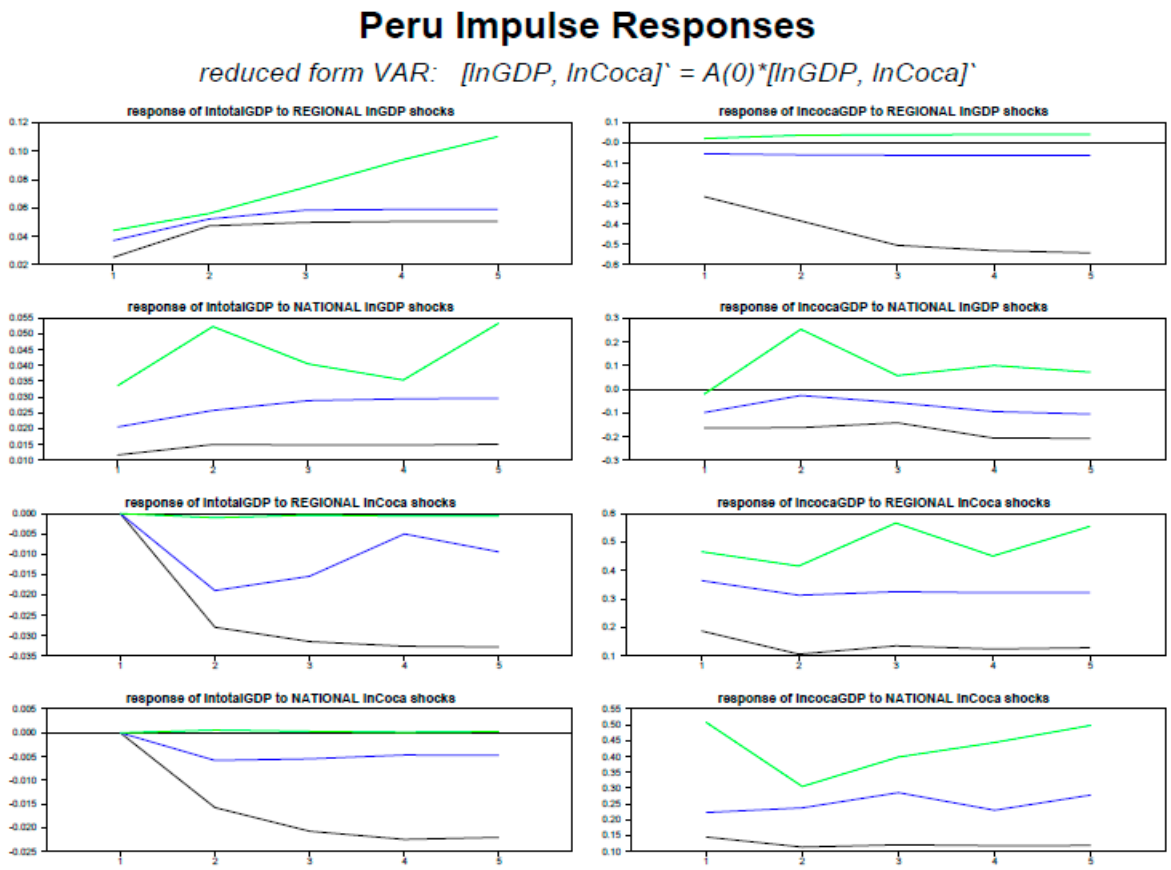
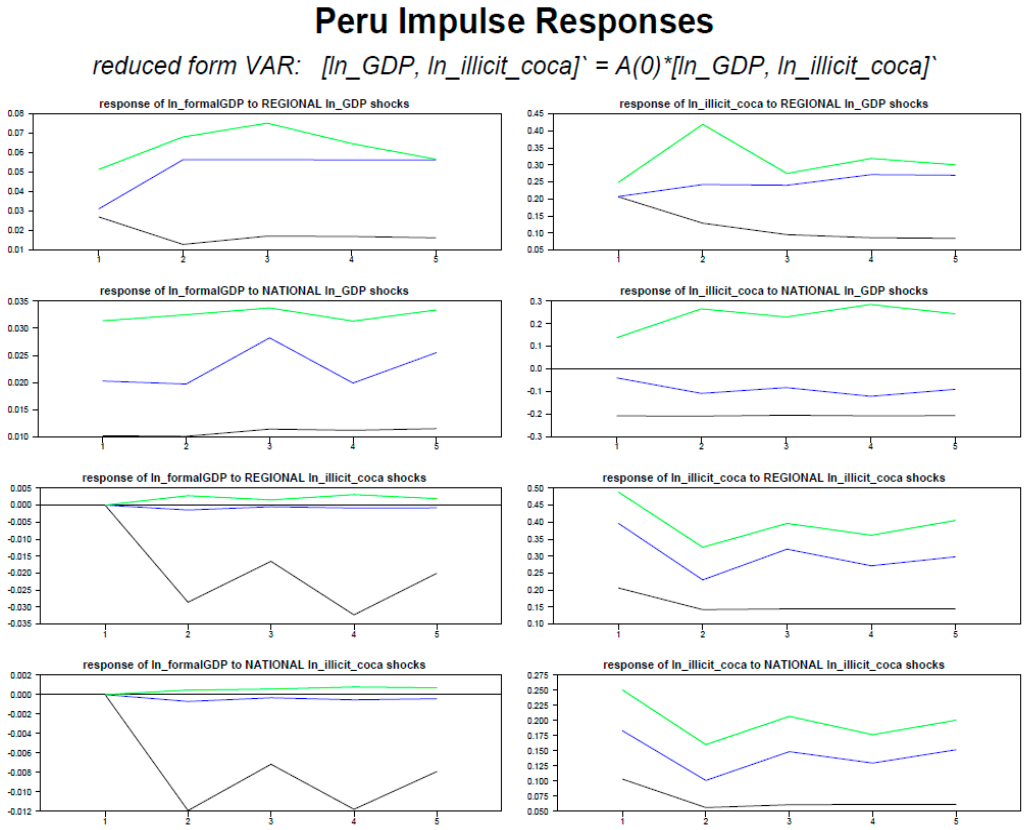
Figure 1a. Peru Impulse Responses: Illicit Coca GDP vs. Formal GDP (Specification1) 1/ 2/



Sources: UNODC; Authors' estimates.
1/ Formal GDP refers to non-coca GDP.
2/ The series on illicit coca GDP are based on ratios of tons of coca leaf cultivation that are derived from the UNODC estimates of coca cultivation by regions for 2008 and 2009.

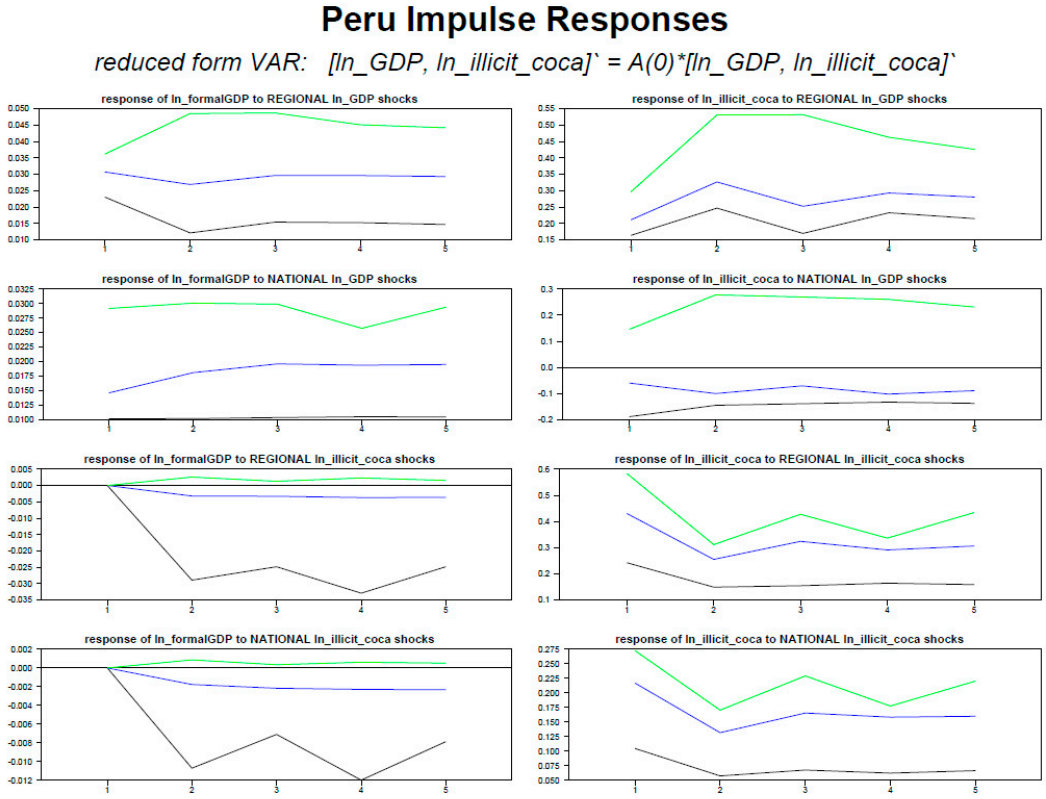
Figure 1b. Peru Impulse Responses: Illicit Coca GDP vs. Formal GDP (Specification 2) 1/ 2/



Sources: IDEI 2009 and 2010; Author's estimates based in table 3 and table 8.

1/ Formal GDP refers to non-coca GDP.
2/The series on illicit coca GDP are based on IDEI estimates.

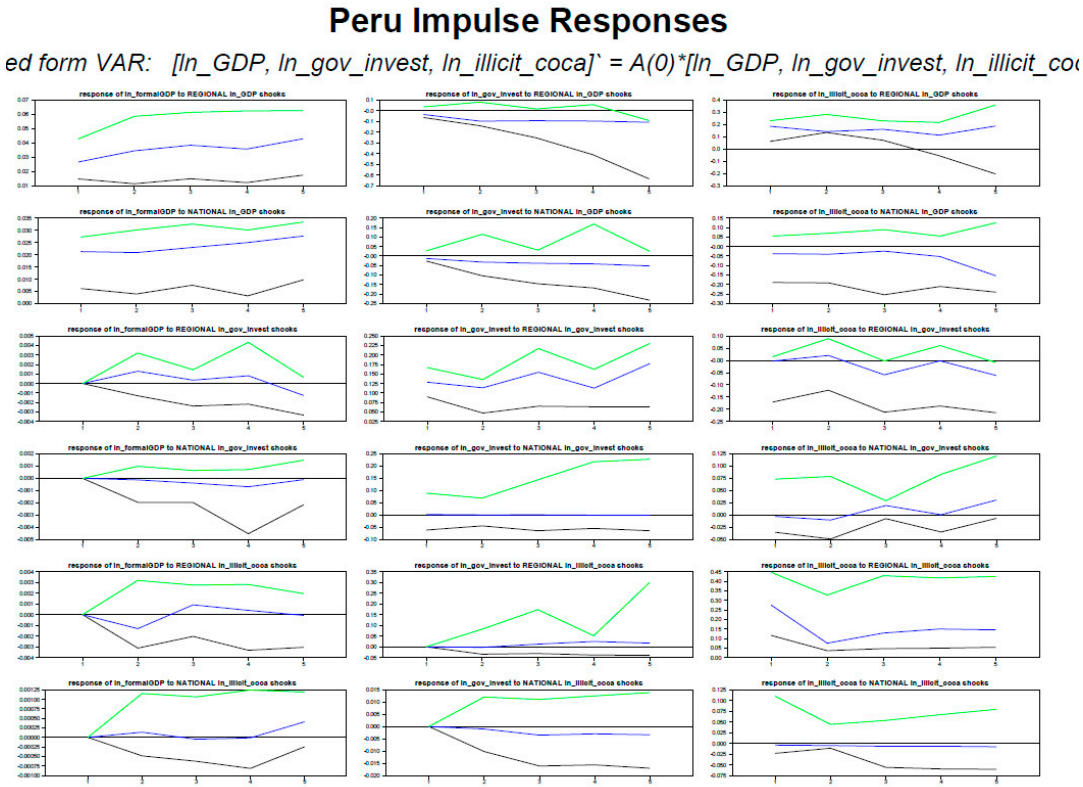
Figure 1c. Peru Impulse Responses: Illegal Coca GDP vs. Formal GDP [23] (Specification 3) **1/ 2/**



[23] Source: Authors' estimates.

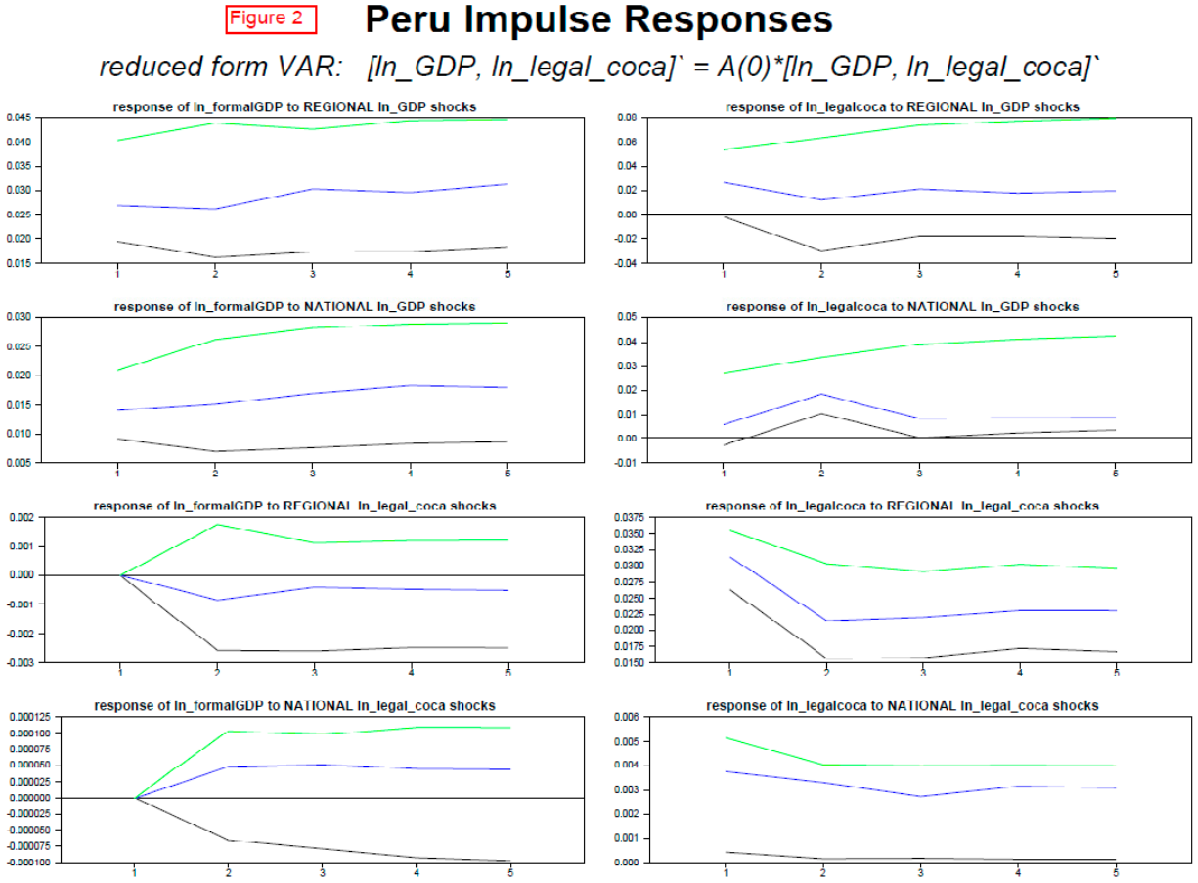
1/ Formal GDP refers to non-coca GDP.
2/ As a robustness check, figure 1c shows how the estimated impulse responses differ when regional estimated baseline tonnage of illicit coca leaf cultivation is adjusted by an increase of 10% for the years 2001 and 2002.

Figure 1d. Peru Impulse Responses: Illicit Coca GDP vs. Formal GDP. (Specification 4) 1/ 2/



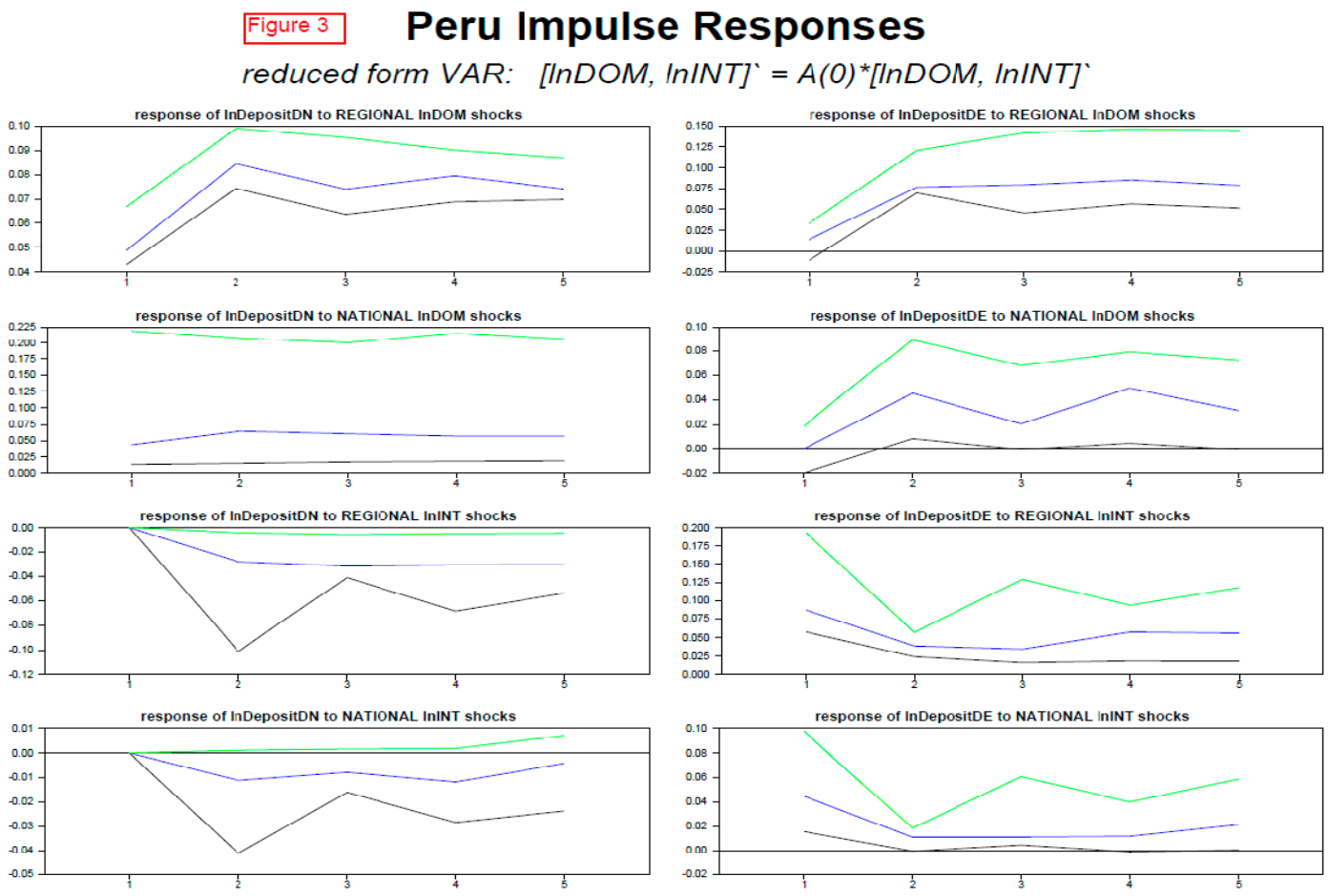
Sources: MEF ; IDEI ; Authors' Estimates.
1/ Formal GDP refers to non-coca GDP.
2/ We reran the reduced form panel VAR as a three variable system with the following ordering of the variables, formal sector GDP, government investment, and estimated illicit coca production.

Figure 2. Peru Impulse Responses: Legal Coca GDP vs. Formal GDP



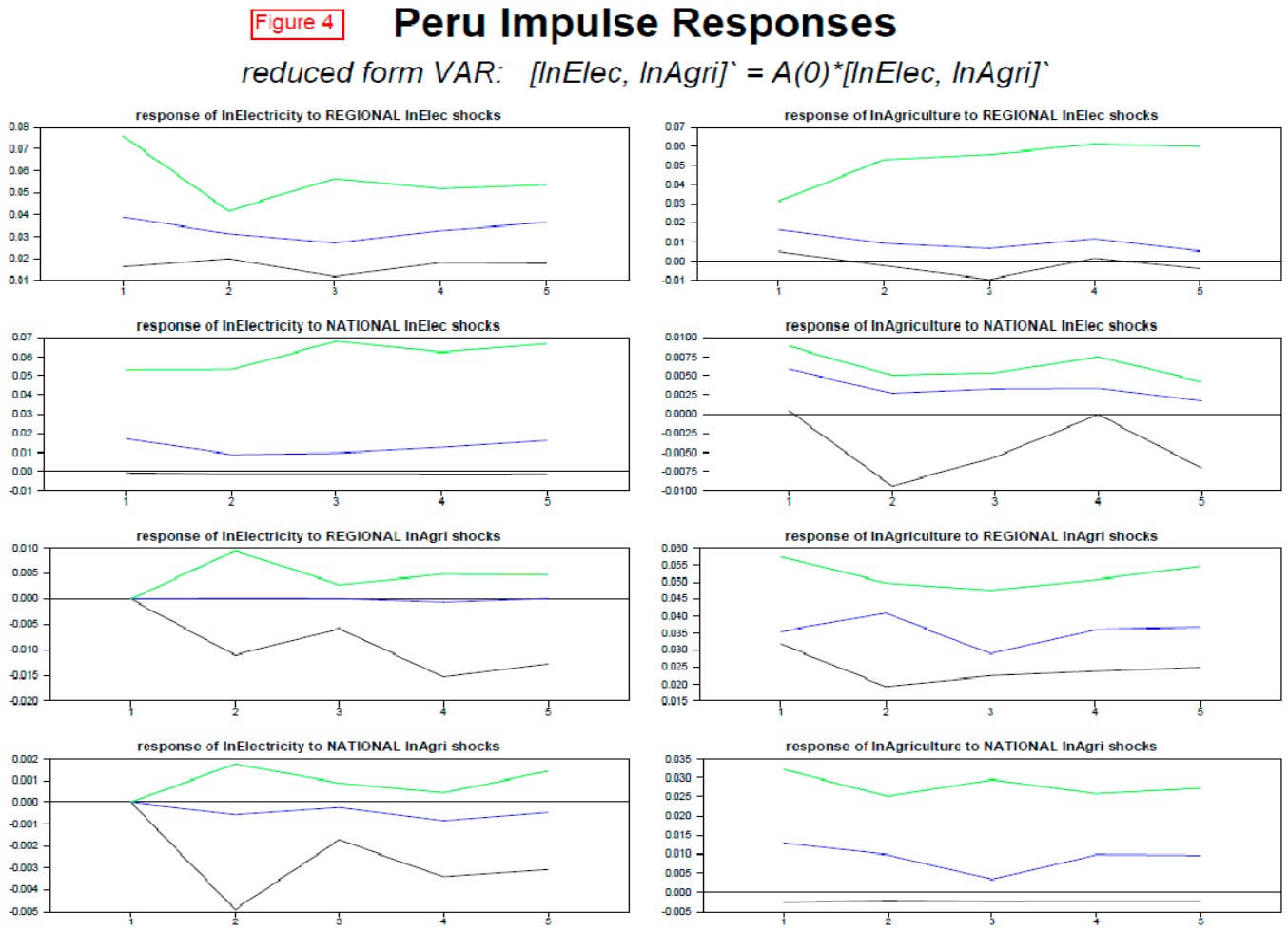
Sources : IDEI 2009 and 2010 ; authors' estimates.

Figure 3. Peru Impulse Responses-Deposits in Domestic Currency vs. Deposits in Foreign Currency



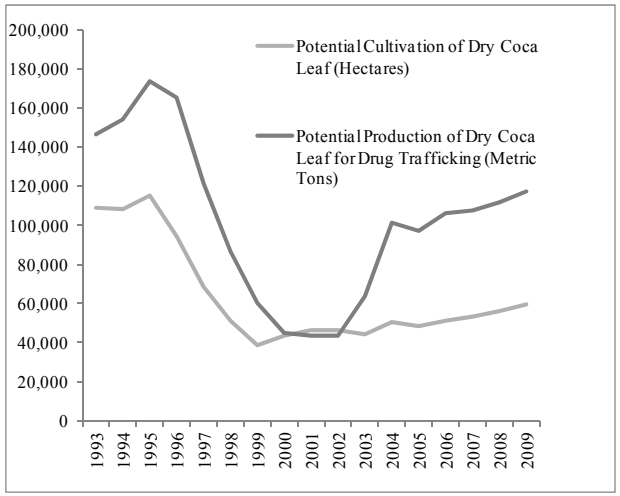
Sources: SBS; Authors' estimates.

Figure 4. Peru Impulse Responses-Agriculture GDP vs. Electricity GDP



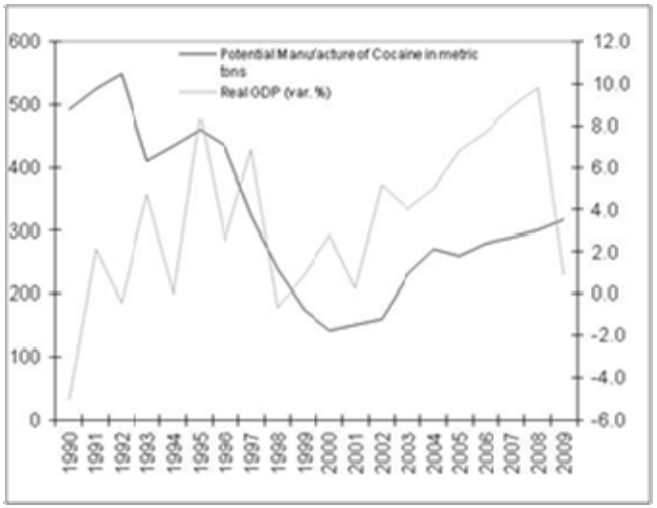
Sources: INEI; Authors'estimates.

Figure 5. Peru: Coca Leaf Cultivation in Hectares and Metric Tons



Sources: UNODC (2010); IDEI (2009)

Figure 6. Peru: Coca Leaf Cultivation in Hectares and Metric Tons



Sources: Garcia and Antezana (2010); Banco Central de Reserva del Peru (2010)

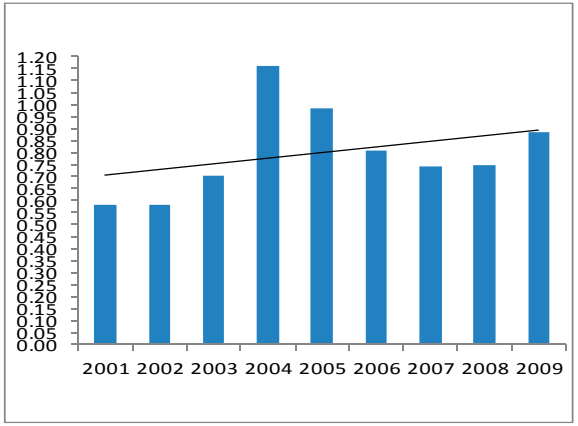


Figure 7. Illicit Coca and Derivatives Ratio (As a percent of Non-Coca GDP) 1/

Source: Authors' estimates.
1/ The estimates are computed as the ratio of illegal coca GDP to national GDP measured in constant 1994 nuevo sol (N.S.) units.

Table 1a. Coca Leaf Cultivated Hectares According to CNC, UNODC, and CADA-CORAH (2001-2009)

Sources	2001	2002	2003	2004	2005	2006	2007	2008	2009
CNC	32,100	34,700	29,250	27,500	34,000	42,000	36,000	41,000	40,000
UNODC-DEVIDA	46,200	46,700	44,200	50,300	48,200	51,400	53,700	56,100	59,900
CADA-CORAH	-	-	-	-	49,481	54,856	64,716	64,218	61,629

Sources: Narcotic Affairs Section, Embassy of the United States in Peru, 2010.

Table 1b. Potential Cocaine Production According to CNC, UNODC, and CADA-CORAH (2007-2009)

	UNODC/DEVIDA			CADA/CORAH			US Government (CNC)		
	Hectares	**Cocaine (44%)**	**Cocaine (72%)**	**Hectares**	**Cocaine (44%)**	**Cocaine (72%)**	**Hectares**	**Cocaine(44%)**	**Cocaine(72%)**
2007	53,682.00	308.82	505.34	64,717.11	380.55	622.71	37,340.00	211.36	345.86
2008	56,060.00	321.01	525.30	64,218.06	381.10	623.62	42,000.00	254.98	417.24
2009	59,926.00	352.13	576.22	61,629.21	368.50	603.00	40,665.00	238.12	389.65

		Hectares	**Cocaine**	
			0.44	0.72
2007	MIN	37,340.00	211.36	345.86
	MAX	64,717.11	380.55	622.71
2008	MIN	42,000.00	254.98	417.24
	MAX	64,218.06	381.10	623.62
2009	MIN	40,665.00	238.12	389.65
	MAX	61,629.21	368.50	603.00

Sources: One source required to be anonymous; UNODC, various years

Table 2. Data Construction

Variables	Definition	Sources
Illegal Coca and Derivatives Gross Value Added ("Illegal Coca")	Measures the gross value added of the illegal coca leaf and derivatives production (coca paste, coca base, and cocaine). The variable is the sum of illegal coca leaf, paste, base, and cocaine gross values added.	See Note below.
Illegal Coca Leaf Gross Value Added	Measures the difference between the gross value added of illegal coca leaf production and the value of intermediate input consumption necessary for the production of illegal coca leaf. The gross value added of illegal coca leaf production per annum is computed as the estimated tonnage of illegal coca leaf cultivation multiplied by the price per ton of illegal coca leaf at the point of cultivation. Intermediate consumption is computed as the value of intermediate inputs per hectare of illegal coca leaf multiplied by the number of estimated hectares of cultivated illegal coca leaf.	Gross value production: Table 8 and Table 12 Intermediate Consumption: Table 11.2 and Table 6. Price: Table 12
Gross Coca Paste Gross Value Added	Measures the difference between the gross value added of gross coca paste production and the value of intermediate consumption of inputs used in gross coca paste production. Gross value added in coca paste production per annum is computed as the estimated tonnage of illegal coca paste multiplied by the price of coca paste per ton. Intermediate input values are computed as the intermediate input per ton of gross coca paste production multiplied by the cost of these intermediate inputs.	Intermediate Consumption : Table 11.3
Washed Coca Paste Gross Value Added	Measures the difference between the gross value added of washed coca paste production and the	Intermediate Consumption : Table 11.3

	intermediate input costs for washed coca paste production. Gross value of production of washed coca paste per annum is computed as the estimated tonnage of coca base by multiplied by the coca paste price per ton. Intermediate consumption is computed as the intermediate consumption per ton of coca base multiplied by the cost of intermediate consumption for coca base production.	
Cocaine Value Added	Measures the difference between the gross value added of the cocaine production and intermediate consumption.	Intermediate Consumption : Table 11.3
Legal Coca Leaf Gross Value Added	Measures the Gross Value Added of legal coca leaf production.	
Legal Coca Leaf Value Added	Measures the difference between the gross value added of production of legal coca leaf and intermediate consumption. Gross value added of legal coca leaf per year is computed as the estimated tons of the legal coca leaf multiplied by the price of legal coca leaf per ton. Intermediate consumption is computed as intermediate consumption per hectare of legal coca leaf multiplied by the estimated number hectares of cultivated legal coca leaf.	Intermediate Consumption: Table 11.1
Agriculture (by region)	Measures the gross value added of the agriculture sector by region.	Instituto Nacional de Estadística e Informática del Perú (2010). Dirección Nacional de Cuentas Nacionales.
Electricity (by region)	Measures the gross value added of the electricity sector by region.	Instituto Nacional de Estadística e Informática del Perú (2010). Dirección Nacional de Cuentas Regionales.
Deposits in Domestic Currency (by region)	Measure the volume of the deposits in banks in N.S by region.	Superintendencia de Bancos y Seguros del Perú (2010).
Domestic in Foreign Currency (by region)	Measure the volume of deposits in banks in foreign currency by region.	Superintendencia de Bancos y Seguros del Perú (2010).

Government Investment (by region)	Measure the national, regional and local government investment (accrued) by region.	Ministerio de Economia y Finanzas (2010)

Note:
Note that in this table we only describe data construction for the second approach. In the first step, we estimate the GDP (Gross Value Added) equivalent of coca and coca derivatives production at the national level annually from 2001-2009 using the same methodology that the National Statistics Institute of Peru (INEI) used to estimate coca and coca derivatives GDP for 2007. Next, we use the IDEI (2009) published estimates of the number of cultivated hectares of illegal and legal coca combined with published estimates of the number of cultivated hectares of the number of tons of illegal and legal coca produced by region in order to calculate the GDP equivalent of illegal and legal coca production by region over the period from 2001 to 2009.

Table 3. Coca and Coca Derivatives Sector Gross Value Added Estimates (2001-2009)[24] (Thousands of 1994 NS)

Production Accounts for Coca and Derivatives	2001	2002	2003	2004	2005	2006	2007	2008	2009
Illegal Coca Leaf									
Gross Production Value	225,559	245,228	2 89,493	564,647	526,807	459.539	438,783	571,969	573,552
Intermediate Consumption	40,908	42,427	39,803	47,176	46,545	47,530	56,482	69,613	69,210
Value Added	184,651	202,801	249,690	517,471	480,262	411.829	382,300	502,356	504,342
Legal Coca Leaf									
Gross Production Value	10,265	13,545	11,482	11,182	11,210	10,979	12,089	12,473	11,517
Intermediate Consumption	1,942	1,962	1,900	1,855	1,829	1,755	1,829	2,013	1,863
Value Added	8,323	11,583	9,582	9,326	9,381	9,224	10,260	10,460	9,654
Gross Coca Paste									
Gross Production Value	549,188	578,738	730,625	1,257,490	1,158,975	1,010,589	1,053,078	1,231,416	1,394,448
Intermediate Consumption	217,260	241,577	294,999	578,430	556,508	486,254	473,091	614,179	569,718
Value Added	331,928	337,161	435,625	696,059	602,467	524,335	579,987	617,237	824,731
Washed Coca Paste									
Gross Production Value	318,986	332,911	427,641	746,389	679,761	592,686	616,967	718,067	814,839
Intermediate Consumption	236,968	247,211	318,459	555,193	506,676	443,403	462,803	540,083	610,331
Value Added	82,018	85,700	109,181	191,196	173,085	149,283	154,164	177,984	204,508
Cocaine Hydrochloride									
Gross Production Value	279,876	292,094	375,209	630,355	589,724	547,246	539,324	568,987	659,840
Intermediate Consumption	248,250	258,696	335,790	583,614	535,551	473,285	497,523	584,752	653,455
Value Added	31,627	33,398	39,419	46,741	54,173	73,960	41,801	-15,765	6,385
Total Illegal Coca Leaf and Derivatives (Illegal Coca GDP)									
Gross Production Value	1,373,610	1,448,971	1,822,967	3,215,881	2,955,266	2,609,880	2,648,152	3,090,439	3,442,679
Intermediate Consumption	743,386	789,910	989,052	1,764,413	1,645,280	1,450,472	1,489,899	1,808,627	1,902,713
Value Added	630,224	659,060	833,915	1,451,468	1,309,987	1,159,408	1,158,253	1,281,812	1,539,966
Total Legal Coca (Legal Coca GDP)									

[24] Sources: Authors' estimates. Note that taxes and subsidies are not relevant and therefore do not enter into calculations for the production of illegal coca and coca derivates. Gross Value Added (GVA) is considered the same as GDP. Please note that the negative value of cocaine GDP in 2008 captures an increase in the cleaned coca paste price which is estimated to be around 14 percent, as well as an important increase in chemical products prices as shown in table 12. However, we estimated that the cocaine price only increased by 3 percent..
It is possible that the chemical products were imported or smuggled and that Peruvian cocaine production finally benefited from a low price of chemicals outside the Peruvian border, since our approach does not account for the price of imported chemicals.

Gross Production Value	10,265	13,545	11,482	11,182	11,210	10,979	12,089	12,473	11,517
Intermediate Consumption	1,942	1,962	1,900	1,855	1,829	1,755	1,829	2,013	1,863
Value Added	8,323	11,583	9,582	9,326	9,381	9,224	10,260	10,460	9,654

Table 4. Estimated Coca Cultivation in Hectares by Coca Valleys (2001-2009)

Coca Valleys	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGUAYTIA	1,051	1,065	510	500	917	1,570	1,610	1,677	2,913
ALTO HUALLAGA	14,481	15,286	13,650	16,900	16,039	17,080	17,217	17,848	17,497
MARAÑON PUTUMAYO	1,250	1,250	450	500	500	968	1,065	1,209	1,666
HUALLAGA CENTRAL	0	0	n.a	n.a	n.a	0	n.a	n.a	n.a
LA CONVENCION	13,980	12,170	12,340	12,700	12,503	12,747	12,894	13,072	13,174
PICHIS-PALCAZU-PACHITEA	350	350	250	300	211	426	1,148	1,378	2,091
RIO APURIMAC	12,600	14,170	14,300	14,700	15,530	15,813	16,019	16,719	17,486
TAMBOPATA-INAMBARI	2,520	2,430	2,260	2,000	2,250	2,366	2,864	2,959	3,519
SAN GABAN	0	0	470	2,700	292	446	464	500	742
ALTO CHICAMA	0	0	0	0	0	0	400	400	498
Others	0	0	0	0	0	0	n.d	298	340
TOTAL	**46,232**	**46,721**	**44,230**	**50,300**	**48,242**	**51,416**	**53,681**	**56,060**	**59,926**

Sources: United Nations Office on Drugs and Crime (2001 - 2010), and IDEI (2009).

Table 5. Estimated Coca Cultivation in Hectares by Region (2001-2009)

Regions	2001	2002	2003	2004	2005	2006	2007	2008	2009
UCAYALI	1,051	1,065	510	500	917	1,570	1,610	1,677	2,913
HUÁNUCO	11,725	13,133	11,976	15,633	14,807	15,848	17,208	17,906	17,816
SAN MARTIN	2,896	2,293	1,775	1,387	1,317	1,402	416	431	423
LORETO	250	250	90	100	100	194	590	670	923
AMAZONAS	400	400	144	160	160	310	382	434	598
CAJAMARCA	300	300	108	120	120	232	93	105	145
CUSCO	17,760	16,421	16,630	17,110	17,162	17,491	17,386	17,760	18,077
PASCO	210	210	150	180	127	256	740	889	1,349
AYACUCHO	7,560	8,502	8,580	8,820	9,318	9,488	10,001	10,438	10,917
JUNÍN	1,260	1,417	1,430	1,470	1,553	1,581	1,536	1,603	1,677
PUNO	2,520	2,430	2,730	4,700	2,542	2,812	3,328	3,459	4,261
LA LIBERTAD	300	300	108	120	120	232	400	401	500
Others	0	0	0	0	0	0	0	298	340
TOTAL	46,232	46,721	44,230	50,300	48,242	51,416	53,690	56,070	59,938

Sources: IDEI (2009) and UNODC (2010)

Table 6. Estimated Illicit Coca Cultivation in Hectares by Region (2001-2009)

Regions	2001	2002	2003	2004	2005	2006	2007	2008	2009
UCAYALI	1,037	1,051	496	486	903	1,556	1,596	1,663	2,899
HUÁNUCO	11,463	12,871	11,714	15,371	14,545	15,586	16,946	17,644	17,586
SAN MARTIN	2,892	2,289	1,771	1,383	1,313	1,398	412	427	374
LORETO	250	250	90	100	100	194	590	670	1,066
AMAZONAS	358	358	102	118	118	268	340	392	420
CAJAMARCA	289	289	97	109	109	221	82	94	127
CUSCO	12,088	10,749	10,958	11,438	11,490	11,819	11,714	12,088	12,640
PASCO	210	210	150	180	127	256	740	889	1,236
AYACUCHO	7,327	8,269	8,347	8,587	9,085	9,255	9,768	10,205	10,690
JUNÍN	1,260	1,417	1,430	1,470	1,553	1,581	1,536	1,603	1,773
PUNO	2,451	2,361	2,661	4,631	2,473	2,743	3,259	3,390	4,176
LA LIBERTAD	0	0	0	0	0	0	31	32	392
Others	0	0	0	0	0	0	0		9
TOTAL	39,625	40,114	37,815	43,873	41,815	44,877	47,014	49,096	53,388

Sources: IDEI (2009 and 2010).

Table 7. Estimated Yield of Illicit Coca Cultivation by Region (2001-2009)

Regions	2001	2002	2003	2004	2005	2006	2007	2008	2009
UCAYALI	0.91	0.90	1.40	1.91	1.91	1.91	1.94	1.91	1.91
HUÁNUCO	1.07	1.06	1.45	1.97	1.97	1.97	1.99	1.98	1.98
SAN MARTIN	1.16	1.15	1.57	2.13	2.13	2.13	2.16	1.58	1.58
LORETO	0.54	0.54	0.73	1.00	1.00	1.00	1.13	1.04	1.04
AMAZONAS	0.60	0.59	0.81	1.10	1.10	1.10	1.13	1.15	1.15
CAJAMARCA	0.59	0.59	0.80	1.09	1.09	1.09	1.11	1.31	1.31
CUSCO	1.16	1.15	1.56	2.13	2.13	2.13	2.16	2.19	2.19
PASCO	0.82	0.81	1.10	1.50	1.50	1.50	1.53	1.47	1.47
AYACUCHO	1.75	1.73	2.36	3.21	3.21	3.21	3.24	3.20	3.20
JUNÍN	1.75	1.73	2.36	3.21	3.21	3.21	3.24	3.30	3.30
PUNO	0.96	0.95	1.29	1.75	1.75	1.75	1.79	1.74	1.74
LA LIBERTAD	0.97	0.96	1.30	1.77	1.77	1.77	1.77	6.22	6.22
Others	1.04	1.02	1.40	1.90	n.a	n.a	n.a	n.a	n.a
Average Yield	1.02	1.01	1.39	1.90	1.90	1.90	1.90	1.93	1.93

Source: IDEI (2009 and 2010)

Table 8. Estimated Tonnage of Illicit Coca Leaf by Region (2001-2009)

REGIONES / AÑOS	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008	2,009
UCAYALI	845	840	689	942	1,731	3,071	3,097	3,179	5,363
HUÁNUCO	11,020	12,126	16,786	30,727	28,754	31,715	33,706	34,897	33,765
SAN MARTIN	3,009	2,334	2,746	2,993	2,809	3,080	891	676	778
LORETO	122	120	65	101	100	201	664	699	1,066
AMAZONAS	192	188	82	132	130	304	386	450	512
CAJAMARCA	154	151	77	121	119	249	91	123	154
CUSCO	12,554	10,940	16,965	24,703	24,541	25,985	25,260	26,496	26,291
PASCO	154	151	164	274	190	396	1,131	1,304	1,866
AYACUCHO	11,478	12,695	19,491	27,973	29,267	30,688	31,687	32,649	34,208
JUNÍN	1,974	2,175	3,339	4,788	5,003	5,243	4,983	5,294	5,674
PUNO	2,099	1,981	3,396	8,246	4,355	4,973	5,847	5,907	7,224
LA LIBERTAD	n.a	n.a	n.a	n.a	n.a	n.a	55	199	674
OTROS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	0	9
TOTAL	43,600	43,700	63,800	101,000	96,999	105,905	107,798	111,873	117,585

Source: IDEI (2009 and 2010)

Table 9. Estimated Legal Coca Cultivation in Hectares by Region (2001-2009)

Region	2001	2002	2003	2004	2005	2006	2007	2008	2009
UCAYALI	14	14	14	14	14	14	14	14	14
HUÁNUCO	262	262	262	262	262	262	262	262	262
SAN MARTIN	4	4	4	4	4	4	4	4	4
LORETO	0	0	0	0	0	0	0	0	0
AMAZONAS	42	42	42	42	42	42	42	42	42
CAJAMARCA	11	11	11	11	11	11	11	11	11
CUSCO	5,672	5,672	5,672	5,672	5,672	5,672	5,672	5,672	5,672
PASCO	0	0	0	0	0	0	0	0	0
AYACUCHO	233	233	233	233	233	233	233	233	233
JUNÍN	0	0	0	0	0	0	0	0	0
PUNO	69	69	69	69	69	69	69	69	69
LA LIBERTAD	300	300	108	120	120	232	369	369	232
Others	0	0	0	0	0	0	0	298	0
TOTAL	6,607	6,607	6,415	6,427	6,427	6,539	6,676	6,974	6,539

Sources: IDEI (2009 and 2010)

Table 10: Eradication by Region in Hectares (2001-2009)

Regions	2001	2002	2003	2004	2005	2006	2007	2008	2009
UCAYALI	3,098	1,005	3,061	3,733	997		2,834		
HUÁNUCO					659		3,894	4,516	
SAN MARTIN	2,992	5,079	3,961	560	4,778	10,136	4,328	5,628	
LORETO	346								
AMAZONAS									
CAJAMARCA									
CUSCO									
PASCO				1,806					
AYACUCHO									
JUNÍN					627				
PUNO				1,507	1,905				
LA LIBERTAD		1,051							
Others									
TOTAL	6,436	7,135	7,022	7,606	8,966	10,136	11,056	10,144	NA

Source: IDEI (2009 and 2010)

Table 11. Intermediate Consumption

Table 11.1. Intermediate Consumption of Legal Coca Leaf from the Cost Structure of 1 Hectare in 2007

Products	Unit	Quantity	Unitary Cost S/	Total Cost S./	%
INPUTS					
Insecticides					
Fungicidas					
Fertilizers					
Foliar Manure					
Adherents					
Tool Maintenance					
Kituche	Unit	9.00	7.00	63.00	11.97
Lampa	Unit	1.50	20.00	30.00	5.70
Cuchupeador	Unit	4.50	5.00	22.50	4.27
OTHERS					
Harvest Container (keperina)	Unit	30.00	3.00	90.00	17.09
Marketing Container	Unit	12.00	16.00	192.00	36.47
Plastic	m.l.	36.00	1.00	36.00	6.84
Freight	arrobas	63.00	1.00	63.00	11.97
Passages	Unit	6.00	5.00	30.00	5.70
Total				526.50	100.00

Source: INEI (2009).

Table 11.2. Intermediate Consumption of Illegal Coca Leaf : Cost Structure of one Hectare in 2007

		Products	Unit	Unit Cost	%
Insecticides					14.3
	Ciperklin	l	2.4	74	
	Tifon 4E	l	2.4	50	
	Lasser	l	0.8	40	
Fungicides					27.5
	Aliette 80 wp	kg	3.6	110	
	Fuji one	l	2.4	85	
	Cupravit	kg	1.2	30	
Fertilizers					20.4
	Ammonium nitrate	bag*50 kg	4	70	
	Campo verde	bag*50 kg	4	40	
	Organic material	bag*50 kg	4	8	
Foliar Manure					13.5
	Extrafollaje	l	16	14	
	Nutrifollaje	l	8	11	
Adherent					1.3
	Citowett	l	1	30	
Others					2.1
	Harvest container	unit	82	0.6	0.6
	Personal transportation	unit	6	80	20.3
Total				642.6	100

Table 11.3 Intermediate Consumption of Gross and Washed Coca Paste, and Cocaine Hydrochloride: Composition per kilogram produced in 2007

Products	Unit	Quantity	Unit Price	%
Gross Coca Paste				
Coca Leaf	kg	100	7.53	0.92
Sulfuric Acid	kg	1.4	3.66	0.01
Sodium Carbonate	kg	1	1	0.00
Kerosene	kg	12.8	4.3	0.07
TOTAL				**1.00**
Washed Coca Paste				
Gross Coca Paste				
Sulfuric Acid	kg	1	3.66	0.00
Sodium Carbonate	kg	1	0.90	0.00
Potassium Permanganate	kg	0.14	214.90	2
TOTAL				**100**
Cocaine Hydrochloride				
Washed Coca Paste	kg	1.25	1,825	93
Acetone	kg	12.00	13.85	7
Hydrochloric Acid	kg	0.46	10.60	0.00
Ethanol/Thinner	kg	0.24	0.60	0.00
TOTAL				**1.00**

Source: INEI (2009). Note that we did not undertake an independent analysis of intermediate consumption for coca leaf and coca derivatives process, and we take as correct the methodology provided by INEI.

Table 12. Summary of Prices

Prices	2001	2002	2003	2004	2005	2006	2007	2008	2009
Illegal Coca Leaf									
Annual Average Farm Dry Coca Leaf (US$/kg)	2.30	2.50	2.10	2.80	2.90	2.50	2.50	3.40	3.20
Exchange rate	3.51	3.52	3.48	3.41	3.30	3.27	3.13	2.93	3.01
Farm Dry Coca Leaf Price(NS/Ton)	8,068	8,794	7,306	9,558	9,560	8,186	7,822	9,948	9,638
Gross Coca Paste									
Average Price Coca Paste (US$/Kg)	560	590	530	632	638	550	600	732	778
Exchange rate	3.51	3.52	3.48	3.41	3.30	3.27	3.13	2.93	3.01
Average Price Coca Paste (NS/Kg)	1,964	2,075	1,843	2,157	2,103	1,801	1,877	2,141	2,343
Washed Coca Paste									
Coca Base (NS/Kg)	2,547	2,691	2,391	2,797	2,727	2,335	2,434	2,777	3,038
Cocaine Hydrochloride									
Cocaine Hydrochloride Price(NS/Kg)	2,793	2,951	2,621	2,952	2,957	2,694	2,659	2,750	3,075
Legal Coca Leaf									
Selling Price (NS/Kg)	3.23	4.28	3.84	3.97	4.09	4.23	4.64	4.64	4.64
Price Indexes (End of Period)									
Chemical Products P I	1.37	3.36	2.19	9.96	8.09	2.28	18.94	30.18	-14.46
Petroleum P I	-43.50	47.60	24.78	43.75	46.95	-13.53	20.12	11.74	-57.42
Other materials PI	-8.30	-11.41	1.60	-2.72	-2.18	-3.82	4.90	6.24	-11.49
CPI	-0.13	1.52	2.48	3.48	1.49	1.14	3.93	6.65	0.25

Sources: Authors' estimates, UNODC (2010), INEI, and Central Bank of Peru.

Note: Note that the prices reported are nominal. The INEI (2009) only reports the drug sector gross value added for 2007. In an attempt to construct the drug sector value added from 2001 to 2009, we assume that technical factors for converting coca leaf into cocaine do not vary over the period. However, to compensate for the volatility that prices have on the illicit drug sector, we assume the prices on 2007 only for year 2007, for the rest of the years; we create a deflator that includes indexes such as the chemical products price index, the petroleum price index, other materials price index, and the CPI. The deflator also takes into account the variations in the coca leaf and coca derivatives prices. There is also substantial uncertainty regarding data on prices. Estimated price of coca leaf varies among sources. The Peruvian experts cite a price of $2.90 per kilogram, while the 2009 UNODC Coca Cultivation Monitoring Survey estimates an average price at $3.20 per kilogram in 2009 with the lowest average price recorded in the VRAE. These prices compare to $1.80 paid by the state-owned National Coca Company (ENACO) in 2009. Domestic wholesale prices for cocaine HCL vary widely depending on the region and the circumstances of the transaction, however, no database is available. Prices are influenced primarily by the price of inputs, transportation costs and the cost of bribery, which is considered a cost of doing business. The cost of bribery is estimated at approximately75% of the proceeds generated by total cocaine production. The average price of cocaine paste in cultivating regions was approximately $778/kg in 2009. The UNODC (2009) estimated the price of cocaine HCL in the Alto

Huallaga growing regions at $1,020/kg and $1,500/kg in Lima. However, representatives from DEVIDA and other experts indicated prices for cocaine about to be exported were as high as $4,050/kg in 2009. For CPI data, we have used end of period values rather than average period values. However, this choice should have little impact on final coca GDP estimates, since CPI primarily only affects some costs in the intermediate consumption of the production of the legal coca leaf cultivation. The illicit coca cultivation and coca derivatives production tend to use chemicals products and petroleum derivatives. Accordingly, we have created an index of chemical, petroleum, and mineral prices as well as CPI, for which the actual contribution of CPI to the index is relatively insignificant.

Table 13. Robustness Check of Coca and Coca Derivatives Sector Gross Value Added Estimates (2001-2009) (Thousands of 1994 NS)

Production Accounts for Coca and Derivatives	2001	2002	2003	2004	2005	2006	2007	2008	2009
Illegal Coca Leaf									
Gross Production Value	225,559	245,228	2 89,493	564,647	526,807	459.539	438,783	571,969	573,552
Intermediate Consumption	55,527	56,089	51,799	57,434	53,642	54,019	56,482	57,609	64,251
Value Added	170,031	189,138	237,693	507,213	473,164	405,339	382,300	514,359	509,300
Legal Coca Leaf									
Gross Production Value	10,265	13,545	11,482	11,182	11,210	10,979	12,089	12,473	11,517
Intermediate Consumption	1,990	1,984	1,918	1,875	1,851	1,792	1,828	1,996	1,897
Value Added	8,274	11,560	9,563	9,306	9,358	9,186	10,260	10,476	9,619
Gross Coca Paste									
Gross Production Value	549,188	578,738	730,625	1,257,490	1,158,975	1,010,589	1,053,078	1,231,416	1,394,448
Intermediate Consumption	239,379	259,319	311,150	597,650	559,042	492,988	473,091	609,678	687,057
Value Added	309,807	319,418	419,474	676,838	599,933	517,600	579,987	621,632	807,391
Washed Coca Paste									
Gross Production Value	318,986	332,911	427,641	746,389	679,761	592,686	616,967	718,067	814,839
Intermediate Consumption	238,757	248,940	320,550	558,009	508,512	444,804	462,803	537,604	608,932
Value Added	80,228	83,970	107,090	188,379	171,248	147,881	154,164	180,984	205,906
Cocaine Hydrochloride									
Gross Production Value	279,876	292,094	375,209	630,355	589,724	547,246	539,324	568,987	659,840
Intermediate Consumption	255,203	265,400	343,955	594,535	542,698	478,796	497,523	574,955	648,020
Value Added	24,673	26,693	31,254	35,819	47,025	68,449	41,801	-5,968	11,820
Total Illegal Coca Leaf and Derivatives (Illegal Coca GDP)									
Gross Production Value	1,373,610	1,448,971	1,822,967	3,215,881	2,955,266	2,609,880	2,648,152	3,090,439	3,442,679
Intermediate Consumption	788,869	791,872	990,952	1,766,268	1,647,108	1,452,227	1,491,729	1,810,639	1,904,576
Value Added	584,741	657,099	832,015	1,449,613	1,308,158	1,157,652	1,156,423	1,279,800	1,538,103
Total Legal Coca (Legal Coca GDP)									
Gross Production Value	10,265	13,545	11,482	11,182	11,210	10,979	12,089	12,473	11,517
Intermediate Consumption	1,991	1,985	1,918	1,876	1,852	1,792	1,829	1,996	1,897
Value Added	8,274	11,560	9,564	9,306	9,381	9,187	10,260	10,260	9,620

PRICE INDEXES Average Period	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009

Chemical Products CPI	0.900833	0.114167	0.28	0.1825	0.83	0.674167	0.19	1.578333	2.521667	-1.21167
Petroleum CPI	3.585	-3.625	3.966667	2.065	3.645833	3.9125	-1.1275	1.676667	0.978333	-4.785
Other Materials	1.194167	-0.69167	-0.95083	0.133333	-0.22667	-0.18167	-0.31833	0.404167	-1.095	-0.9575
CPI	3.8	1.98	0.19	2.26	3.66	1.62	2.00	1.77	5.78	2.93

Source: Author's estimates.
Note: This table was constructed as a robustness check to investigate the use of period average CPI values on national estimates, by comparison with table 3, which uses end of period CPI values. Coca and coca derivative prices are reflected in table 12.