Macroeconomic Volatility: The Role of the Informal Economy

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Abstract

Many countries have a large informal economy that is typically poorly measured in the national accounts. In this paper I develop a two sector real business cycle model where one sector is formal and another sector is informal, and explore quantitatively what are the consequences of having an informal sector for measured business cycles. I show that if the informal economy is poorly measured, then the model can account for two business cycle patterns that are puzzling from the point of view of standard business cycle models. In particular, this model can generate a large volatility of measured consumption, and a high volatility of measured consumption relative to output, as observed in many developing countries and some developed countries. My results imply that studies of business cycles should recognize the importance of the informal sector, and that mis-measurement can affect measured cyclical fluctuations.

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1 Introduction

In many countries (particularly in developing countries) there is a large informal economy\(^1\)–value added creating activities which are not taxed or registered by the government–that is typically poorly measured in national account statistics. In this paper I develop a two sector real business cycle model where one sector is formal and another sector is informal, and explore quantitatively what are the consequences of having an informal sector for measured business cycles.

I show that, if the informal economy is poorly measured, then the model can account for two business cycle patterns that are puzzling from the point of view of standard business cycle models. In particular, relative to a standard one-sector business cycle model featuring consumption smoothing, this model can generate a large volatility of measured consumption, and a high volatility of measured consumption relative to output. Interestingly, this means that the model can rationalize high observed volatility of measured consumption relative to output in both developing countries and some developed countries that have a large informal economy. These results illustrate the importance of the informal sector in order to understand business cycle fluctuations.

A large informal sector which is poorly measured by definition due to its underground nature can be reflected in a higher volatility of consumption because agents can substitute formal for informal consumption over the cycle and we only observe movements in and out of the formal sector. Furthermore, consumption can be more volatile than output if formal and informal consumption goods are more substitutable than formal and informal investment goods.

Let me be more specific. In the standard one-sector model–where output is used for consumption and investment–volatility arises due to aggregate productivity shocks, investment is more volatile than consumption, and as a result, output is more volatile than consumption. Now imagine a model where consumption and investment goods are produced by both a formal and an informal sector, each sector faces an idiosyncratic productivity shock, and consumption goods are substi-

\(^1\)In developing countries the informal sector has been estimated to be around 34% of GDP. In developed countries it has been estimated to be around 13% of GDP. However, there is a subset of developed countries for which it is considerably higher at around 20% of GDP (see Schneider (2004)).
tutes\textsuperscript{2} and investment goods are complements.\textsuperscript{3} First, let's assume that both sectors are well measured. In this case, when the informal sector receives a higher productivity shock than the formal sector, agents substitute formal for informal consumption, and due to the negative correlation of consumption goods, measured volatility of consumption is low. At the same time, as investment goods are complements, the correlation between formal and informal output is not as negative as that of consumption, so the volatility of consumption is lower than that of output as in the standard one-sector model. Now, let's assume that the formal sector is measured but the informal sector is not. In this case, when the informal sector receives a higher productivity shock than the formal sector, agents substitute formal for informal consumption, but, this time, as only the formal sector is measured, we observe a highly volatile consumption. Furthermore, when the informal sector is not measured, consumption can be more volatile than output because the substitution of consumption goods from the formal to the informal sector over the business cycle is greater than that of investment goods. In other words, the volatility of formal output can be lower than that of formal consumption because investment is not reallocated as much as consumption (due to the complementarity of investment goods).

I write down and parametrize a model like the one described above to assess the quantitative importance of these mechanisms. In my numerical exercise I study how the relative volatility of consumption to output changes when the size of the informal economy increases, both when this sector is fully measured and in the extreme case that it is not measured at all. I find that even when the substitution elasticity of consumption goods is as low as two, the relative volatility of consumption to output is higher in countries with large unmeasured informal sectors. Secondly, I find that when the unmeasured informal sector is around 30\% or more of GDP, consumption is more volatile than output. Finally, my results imply that if countries could accurately measure the informal sector in their national accounts then their observed relative volatility of consumption to output would fall significantly and we would not observe such a big variation in this measure between countries.

\textsuperscript{2}Section 4 has a detailed discussion on the elasticity of substitution of formal and informal consumption.
\textsuperscript{3}See Section 4 for discussion on the complementarity of investment.
Hence, studies of business cycles should recognize the importance of the informal sector and how mis-measurement can affect measured cyclical fluctuations.

Note that the model presented here is not a model of the informal sector per se. In other words, the size of the informal economy is taken as given, and the aim is not to explain the existence of the informal sector or what mechanisms promote its growth. The objective is to show that, given the existence of an informal sector, theory predicts that when this sector is poorly measured in the national accounts, it is natural to observe a higher relative volatility of consumption to output.

This paper follows the home production literature and the literature on emerging market business cycles. \(^4\) Note that the mechanism generating a higher volatility of consumption in the model is essentially the same as in home production models (see Benhabib et al. (1991), pg. 1168). Nevertheless, the informal sector is different from the household sector because the former produces investment goods while the latter does not, and investment goods are key to explain how consumption can be more volatile than output.

The “informal sector” channel presented in this paper, is a complementary mechanism driving high consumption volatility to other mechanisms in the literature, such as Neumeyer and Perri (2005) and Aguiar and Gopinath (2007). Neumeyer and Perri construct a model of a small open economy, where the real interest rate is decomposed in an international rate and a country risk component; the key features of the model are that country risk is affected by fundamental shocks and there is working capital. They find that if interest rate shocks are large compared to productivity shocks, their model induces equilibrium consumption to be more volatile than output. Aguiar and Gopinath propose a small open economy model which is subject to volatility in trend growth due to frequent policy regime switches. They find that shocks to trend growth are the primary source of fluctuations in emerging markets. Their model predicts that consumption volatility (driven by income shocks) should exceed income volatility in emerging economies.

Finally, the paper relies on the literature that is devoted to measuring the informal economy

\(^4\)This excess volatility of consumption puzzle has been documented by Rand and Tarp (2002), Mendoza (1995), Neumeyer and Perri (2005) and Aguiar and Gopinath (2007) among others.
through different methods (see Schneider (2004) and Schneider and Enste (2000)) and although there is an extensive literature that focuses on the causes of the informal sector (see Rauch (1991) and Quintin (2008) for examples) this paper is not related to it, as I take the informal sector as given.

The rest of the paper proceeds as follows: Section 2 shows the relationship between the relative volatility of consumption to output and the size of the informal economy, Section 3 describes the model economy, Section 4 explains the calibration, Section 5 shows the results, and the last section summarizes my findings.

2 Relative Volatility of Consumption to Output and the Informal Economy

In this section I begin by defining the term informal economy. I briefly discuss two methods that are commonly used to estimate its size and the average results obtained by applying these methods to developed and developing countries. These results, not surprisingly, establish that rich/developed countries have smaller informal economies than poor/developing countries. Nevertheless, they also show that there is a subset of developed countries which have a large informal sector. I then discuss how incorporating the informal economy when compiling the national accounts is a difficult task due to its underground nature. The section ends by showing that there is a systematic relationship between volatility and the size of the informal sector: the relative volatility of consumption to output \( \frac{\sigma(c)}{\sigma(y)} \) is higher in countries with large informal sectors.

I define the informal economy as those value-added-creating activities which are not taxed or registered by the government and are therefore difficult to measure (see Table 4 in the Appendix for a detailed taxonomy of the informal economy). There are several ways of indirectly measuring the size of the informal economy. The currency-demand approach assumes that informal activities operate with cash, and it calculates the correlation between currency demand and “tax pressure”. If the tax burden and the demand for money increase together then the increased demand for money
is attributed to an increase in the size of the informal economy (see Schneider and Enste (2000)). Another approach is the dynamic multiple-indicators multiple-causes model (DYMIMIC), which considers multiple causes and indicators of the informal economy at the same time. This approach estimates a model in which the informal economy is an unobserved variable. The model links this unobserved variable to observed indicators (like electricity use, for example). The Appendix contains a more detailed description of commonly used indicators. For details on the DYMIMIC approach, refer to Schneider and Enste (2000). Even though each approach has its own problems\(^5\), each methodology used to measure the informal sector allows comparison across countries. In other words, if we use the same methodology on all countries, we can compare the estimates of the size of the informal economy among them. Furthermore, in order to be more agnostic towards the different methodologies to measure the informal sector, the measures shown in this section are an average of the results obtained using the currency-demand approach and the DYMIMIC approach (see Schneider (2004)).

Schneider (2004) shows that in rich countries the informal sector is between 8% and 23% of GDP while in poor countries it is between 20% and 60% of GDP. Nevertheless, most developed countries have an informal sector that is between 8% and 17% of GDP, while Scandinavia (Sweden, Norway and Denmark), Spain, and Portugal have an informal sector that is between 17% and 22% of GDP. This last group of developed countries has an informal economy that is larger than that of the average developed country and that can be of the same size as that of some developing countries. Later, I will show that the size of the informal economy is not the only similarity between Scandinavia, Spain, and Portugal and developing countries; they also share a higher relative volatility of cyclical consumption.

Countries follow the methodology suggested in the book “System of National Accounts, 1993” (SNA93) to measure macroeconomic variables. This methodology requires that they calculate the income side of the accounts using value added and then measure the expenditure side by only

\(^5\)See Appendix for a discussion on the pros and cons of different methodologies used to measure the informal economy.
calculating investment, government expenditure and net exports. Hence, consumption is a residual. OECD countries (or any country for that matter) can complement the SNA93 methodology with that suggested in *“Measuring the Non-Observed Economy-A Handbook”*, published by the OECD (2002). This book gives a detailed decomposition of the informal economy (which the book refers to as the non-observed economy) and then it describes several methodologies that can be used to identify and quantify the informal economy so that it can be incorporated into the national accounts. The main and most recommended approach is to use household surveys.

Through a household survey it is possible to measure income and expenditure. The resulting discrepancy attained by comparing these results with those obtained by following the SNA93 approach might point out production and consumption of informal goods and, hence, the adjustments that need to be made to the accounts. Another approach is to use the household survey to pin down the labor input used in the informal sector. To do so, one can compare the number of jobs declared by firms with the number of employed people found through the household survey. The number of employed people exceeding the number of jobs represents the informal workforce. Once the informal number of workers is identified, informal workers can be attributed the same gross compensation (net of social contributions) as similar, formal workers. These two methods do not address the informal economy directly, so the results cannot be distinguished from statistical discrepancy and are subject to willingness to report issues as discussed later.

If household surveys are directly used to uncover the size of the informal sector, the results will depend directly on the questions asked by the survey and the definition of the informal economy that is used. For example, the informal sector may be defined as those people who do not contribute to a pension fund, but this definition clearly excludes several important elements that would describe the informal economy otherwise. Another common definition is that a person is considered to work in the informal economy if they work for a firm that has \( N \) or fewer workers. This is a very strong assumption because a firm can be very small but still comply with the law. That is, a firm’s production can be reported to the authorities, meaning that its value added already appears in the

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6This is the approach used in Italy (see Bovi (2007)).
GDP no matter how small the firm is. On the other hand, if a direct questionnaire is used, people are usually unwilling to admit (unwilling to report) that they are informal workers, either because they feel afraid of getting caught or because they feel ashamed. This makes it difficult to estimate the extent of undeclared work. The disadvantages of this method are discussed in great detail by Mogensen et al. (1995). As a result, it is natural to think that countries with larger informal sectors are missing a bigger fraction of it in the national accounts.

Many poor and middle-income countries either do not have household surveys or have surveys with poor coverage (they only cover the main metropolitan areas). Hence, they cannot use these surveys to help adjust their national accounts for the informal economy. To the extent that these surveys can be used, they only capture the informal economy of the areas included in the survey.\(^7\) It is more difficult for poor and middle-income countries to correct their accounts for their much larger informal economies.\(^8\)

In summary, accounting for the informal economy in the national accounts is difficult. Developed countries devote more resources to its measurement than developing countries, but, no matter what the efforts to measure it are, countries are missing a big slice of the pie. This mis-measurement is especially relevant for those countries with large informal sectors.

I use an average of the currency-demand and DYMIMIC approach results to compare the size of the informal sector among various countries and to show its relationship to the relative volatility of consumption to output. Table 1 shows the average size of the informal sector\(^9\) and the average relative volatility of consumption to output for thirteen developing and fourteen developed countries.\(^10\) Developed countries are separated into two groups: Scandinavia, Spain, and Portugal and

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\(^7\) I thank Jaime Vallecilla, Mario Nigrinis and José Ignacio Lopez for providing information on the measurement of the national accounts in developing countries.

\(^8\) A middle-income country that is an exception is Peru. Peru has been using methods to improve the measurement of its informal sector since the 1980’s and has been doing it in a continuous manner since 2003. See http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0166/Libro.htm for further information. This observation goes in line with my theory that mis-measurement causes high relative volatility of consumption to output. Peru is the only developing country in the sample with a relative volatility of consumption to output below one.

\(^9\) The estimates in the table correspond to the 2002-2003 period; there are also estimates for the 1999-00 and 2001-02 periods, but they are not significantly different, see (Schneider (2004)).

\(^10\) The countries in the sample are the same as in Aguiar and Gopinath (2007) plus the U.S. The countries are middle-income and developed economies that have at least 40 quarters of data, excluding all G-7 countries other than Canada
all the rest. The table illustrates how, on average, the higher the relative volatility of consumption to output is, the larger the size of the informal economy. More surprisingly, it shows that, on average, Scandinavia, Spain, and Portugal have a relative volatility of consumption to output that is greater than one, as is the case for developing economies. Hence Scandinavia, Spain, and Portugal have a larger informal economy than the other developed countries and share a higher volatility of cyclical consumption with developing countries.

Figure 1, constructed with data from Schneider (2004), Neumeyer and Perri (2005), and Aguiar and Gopinath (2007), shows a scatter-plot with the size of the informal economy and the relative volatility of consumption to output for the same sample of countries as in Table 1. The important thing to notice is that there is a high correlation between the relative volatility of consumption to output and the size of the informal sector.\(^{11}\) In general, countries that have a higher relative volatility of consumption to output have a large informal sector that is difficult to measure.

Table 1: Comparison of the average relative volatility of consumption to output and the average size of the informal economy (% of GDP, 2002-03)

<table>
<thead>
<tr>
<th></th>
<th>$\frac{\sigma(c)}{\sigma(y)}$</th>
<th>Informal Economy (% of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed Countries</td>
<td>0.81</td>
<td>13</td>
</tr>
<tr>
<td>Scandinavia, Spain &amp; Portugal</td>
<td>1.20</td>
<td>20</td>
</tr>
<tr>
<td>Developing Countries</td>
<td>1.53</td>
<td>36</td>
</tr>
</tbody>
</table>


Motivated by these facts, I develop a model in the next section to study how the size of the informal sector and whether it is well measured in the national accounts impacts the relative volatility of consumption to output. Given that my analysis is based on unmeasured economic activity, the model is in the spirit of home production that is not being measured (see Benhabib et al. (1991)). I and the U.S. The countries in Neumeyer and Perri (2005) are a subset of those in Aguiar and Gopinath (2007).

\(^{11}\) The correlation is about 0.75.
do a quantitative analysis to see how the relative volatility of consumption to output changes when the size of the informal economy increases, both when this sector is fully measured and in the extreme case that it is not measured at all.

3 The Model Economy

I develop a model based on the household production literature but with several important differences. In the benchmark model there is a formal and an informal sector. Both produce consumption goods and, in contrast with the household production literature, both sectors produce investment...
goods. I include the production of investment goods in the informal sector because construction is one of the sectors with the highest share of informal workers. In Argentina 72.6% of construction workers are informal, 68.3% in Brazil and 56.8% in Mexico, Gasparini and Tornarolli (2007). Investment goods from the formal and informal sector are aggregated into a composite investment good.

Households can work in the formal sector and pay labor income taxes or work in the informal sector and avoid paying taxes. They consume both formal and informal consumption goods, accumulate the composite investment good, and supply labor and capital to the formal and informal sector for production. The government collects the labor tax from the formal sector and finances an unproductive expenditure.

To test the sensitivity of the results, I solve for two special cases of the model. In one case I shut down the production of informal investment goods and in the other special case I vary the mobility of capital across the two sectors. Since I am interested in whether the presence of unmeasured market activity has an important quantitative implication in the standard real business cycle model, I abstract from open economy factors. I use the model to do a sequence of computational experiments to assess the effect of the size and lack of measurement of the informal sector on the relative volatility of consumption to output.

**The Benchmark Model**

**Formal Sector**

The formal sector is competitive. Producers maximize profits by choosing the level of capital and labor given the rental rate of capital, the real wage and a technology to produce output, and investment goods. The technology is a standard Cobb-Douglas production function. The problem

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12 Although they are very important, I don’t think they are determinant for my results. In an open economy setting, the formal sector would be tradable and the informal sector non-tradable; hence, the formal sector would be subject to terms of trade shocks while the informal sector wouldn’t. The effect of such a difference would be analogous to having less correlated productivity shocks: hence, I anticipate that in such setup the results would be very similar to those in my benchmark model when the correlation between formal and informal productivity shocks is low. The low correlation case is shown in Section 5.1.3.
faced by the formal firms is

$$
\max \{k_f, h_f\} \Pi_f = A_f^\alpha (h_f^{1-\alpha}) - r_f k_f - w_f h_f \forall t,
$$

where $h_f$ is formal labor demand, $k_f$ is formal capital demand, $r_f$ is the return to capital, $w_f$ is the wage in the formal sector, and $A_f$ is the productivity of the formal sector. $\log(A_f)$ follows a standard autorregressive process of order one. The first order conditions for the producers of the formal good are standard.

**Informal Sector**

This sector is also competitive. Producers of informal goods maximize their profits by choosing the level of capital and labor given the rental rate of capital, the real wage, and a technology to produce output. The problem faced by the informal firms is

$$
\max \{k_i, h_i\} \Pi_i = p_t A_i^\theta (h_i^{1-\theta}) - r_i k_i - w_i h_i \forall t,
$$

where $p_t$ is the relative price of informal to formal goods, $h_i$ is informal labor demand, $k_i$ is capital demand by the informal firm, $w_i$ is the wage in the informal sector, and $A_i$ is the productivity of the informal sector. $\log(A_i)$ follows a standard autorregressive process of order one. The first order conditions for the producers of the informal good are standard.

**Investment Sector**

There is a representative firm that buys investment goods from the formal and informal sector and combines them to produce a single investment good $x_t$, where

$$
x_t = \left( \eta (x_f^\nu + (1-\eta) (x_i^\nu) \right)^{1/\nu}.
$$

This final investment good is purchased by households. The problem of the investment firm is given by

$$
\max \{x_f, x_i\} \Pi_i = q_t \left( \eta (x_f^\nu + (1-\eta) (x_i^\nu) \right)^{1/\nu} - x_t - p_t x_i,
$$
where $q_t$ is the relative price of final investment goods to formal consumption goods, $x^f_t$ is investment produced by the formal firm, and $x^i_t$ is investment produced by the informal firm.

### Representative Household

The problem of the representative household is to maximize the discounted expected value of its lifetime utility subject to its budget constraint:

\[
\max_{\{c^f_t, c^i_t, l^f_t, l^i_t, k_t\}} E_t \left( \sum_{t=0}^{\infty} \beta^t u(c^f_t, c^i_t, l^f_t, l^i_t) \right)
\]

subject to

\[
(1 - \tau)w^f_t l^f_t + w^i_t l^i_t + r_t k_t = c^f_t + p_t c^i_t + q_t x_t,
\]

and

\[
x_t = k_{t+1} - (1 - \delta) k_t,
\]

and

\[
x_t \geq 0,
\]

where $l^f_t$ is labor supplied to the formal sector, $l^i_t$ is labor supplied to the informal sector, $\tau$ is the tax on formal labor income, $k_t$ is total capital stock, $c^f_t$ is consumption of formal goods, $c^i_t$ is consumption of informal goods, and $p_t$ is the relative price of informal to formal goods.
The utility function is\textsuperscript{13}

\begin{equation}
    u(c_f^t, c_i^t, l_f^t, l_i^t) = \left( \frac{b}{e} \right) \ln \left[ a(c_f^t)^e + (1 - a)(c_i^t)^e \right] + (1 - b) \ln \left[ 1 - l_f^t - l_i^t \right]
\end{equation}

where $l_f^t + l_i^t \leq 1$ and $e$ determines the intratemporal elasticity of substitution between formal and informal goods. This is the same utility function used by Benhabib et al. (1991) in their home production model.

Notice that, as in the household production literature, labor is free to flow between sectors. This free mobility assumption is consistent with evidence from the literature on labor market segmentation between the formal and informal sector. Magnac (1991), using an integrated microeconomic model derived from a labor supply model in a four-sector labor market with explicit demand constraints and using data on women’s labor force participation in the main towns of Colombia in 1980, concludes there is free mobility within the labor market. Maloney (1999), using detailed panel data from Mexico, studies patterns of worker mobility between sectors and concludes that there is no significant segmentation between the formal and informal division. Finally, Pratap and Quintin (2004), using parametric and semi-parametric methods and data from Argentina’s household survey, find that there is no evidence to support “the mainstream view that labor markets are segmented along formal/informal lines in developing nations such as Argentina”.

**Government**

The government taxes households for their labor income from the formal sector. The government is unaware of the time households spend working for the informal sector and is therefore unable to tax this income.

The gathered revenue is used to cover unproductive expenditure. The government satisfies a

\textsuperscript{13}The utility function used here is a specific case ($\sigma = 1$) of the following functional form: 

\begin{equation}
    u(c_f^t, c_i^t, l_f^t, l_i^t) = \left\{ \left[ a(c_f^t)^e + (1 - a)(c_i^t)^e \right]^{\frac{b}{e}} \right\}^{\left( \frac{1}{1 - \sigma} \right)} \left( 1 - l_f^t - l_i^t \right)^{\left( \frac{1}{1 - \sigma} \right)}
\end{equation}

This functional form is convenient because it delivers constant hours along a balanced growth path. I assume $\sigma = 1$ because the logarithmic case is often studied and it has been shown that varying $\sigma$ over a reasonable range doesn’t significantly change the results of the model, (Hansen (1988)).
budget constraint every period:

\[ \tau w_f^t h_f^t = g_t. \]

**Competitive Equilibrium**

A recursive competitive equilibrium is a value function \( V(k, K, A_f, A_i) \); decision rules for the household \( k^l(k, K, A_f, A_i), c^f(k, K, A_f, A_i), c^i(k, K, A_f, A_i), l^f(k, K, A_f, A_i) \) and \( l^i(k, K, A_f, A_i) \); decision rules for the formal firm \( k^f(K, A_f, A_i) \) and \( h^f(K, A_f, A_i) \); decision rules for the informal firm \( k^i(K, A_f, A_i) \) and \( h^i(K, A_f, A_i) \); decision rules for the investment firm \( x^f(K, A_f, A_i) \) and \( x^i(K, A_f, A_i) \); price functions \( w^f(K, A_f, A_i), w^i(K, A_f, A_i), r(K, A_f, A_i), p(K, A_f, A_i) \) and \( q(K, A_f, A_i) \) and a law of motion for aggregate capital \( K' = H(K, A_f, A_i) \), such that:

- Given prices, the decision rules for the household solve the household’s problem.
- Given prices, the decision rules for the formal firm solve the formal firm’s problem.
- Given prices, the decision rules for the informal firm solve the informal firm’s problem.
- Given prices, the decision rules for the investment firm solve the investment firm’s problem.
- Markets clear:

\[
\begin{align*}
    h^f_t &= l^f_t, \\
    h^i_t &= l^i_t, \\
    k^f_t + k^i_t &= k_t, \\
    x_t &= \left( \eta(x^f_t)^\nu + (1 - \eta)(x^i_t)^\nu \right)^{1/\nu}, \\
    A^f_t (k^f_t)^\alpha (h^f_t)^{1-\alpha} &= c^f_t + x^f_t + g_t,
\end{align*}
\]
$$A_t^f(k_t^f)\theta(h_t^f)^{(1-\theta)} = c_t + x_t^f,$$

- Perceptions are correct


## 4 Calibration and Calculation of Equilibrium

Some of the parameters in the model are common to the business cycles literature. These parameters are the discount factor ($\beta$), the depreciation rate ($\delta$), the capital intensity of the formal sector ($\alpha$), the tax rate ($\tau$), and the persistence of the productivity shock of the formal sector ($\rho_f$). For these parameters I’ll use representative values ($\beta = 0.99$, $\delta = 0.025$, $\alpha = 0.36$, $\tau = 0.23$, $\rho_f = 0.95$), moreover, the results are insensitive to changes in their values.

Other parameters are specific to this study; therefore, I use some data that helps me choose a benchmark value for these parameters as well as a range of values around the benchmark case.

Survey evidence shows that production is more capital-intensive in the formal economy (see Thomas (1992)). This forces me to choose $\theta < \alpha$. I choose $\theta = 0.2$ for the benchmark case and then experiment with $\theta = 0.3$ and $\theta = 0.1$.

We have no evidence on the persistence of the productivity shocks of the informal sector ($\rho_i$); hence, to maintain symmetry in the model I assume it equal to $\rho_f$. If we assume $\rho_i < \rho_f$ there is no significant difference in the results (see Figure 8 in the Appendix).

For the correlation of the productivity shocks between the two sectors I use 0.66. This value is used in the home production literature (see Benhabib et al. (1991)). I check the sensitivity to this parameter using correlations of 0 and -0.66. The standard deviation of the shocks is fixed in 0.007 following Benhabib et al. (1991).

Regarding the substitution between formal and informal investment goods, there is evidence that the construction industry is highly informal (see Gasparini and Tornarolli (2007)). Given that investment includes both construction and durable equipment, and that construction is a relative
complement to durable equipment, I choose the elasticity of substitution between investment goods \((\frac{1}{1-\nu})\) to be 0.5 in the benchmark case and experiment with elasticities of 2 and 0.1.

The share of informal investment is higher in countries with large informal sectors; hence, the share of formal investment, \(\eta\), is set such that it decreases as the size of the informal sector increases so that the share of informal investment increases with the size of the informal sector. Specifically, \(\eta\) is set such that the share of informal investment goes from 8% to 60%.

For the elasticity of substitution between formal and informal consumption goods \((\frac{1}{1-e})\), I choose 8 as the benchmark and experiment with a range that goes from 2 to 20. Evidence indicates that formal and informal consumption goods are very good substitutes. Two of the sectors with the highest share of informal workers are commerce and domestic servants, Gasparini and Tornarolli (2007). For example, there is a large degree of informality in the retail sector, and it is generally the case that consumption goods sold by a formal vendor are the same as those sold by an informal one. To illustrate this, there are two very good and different examples that give a sense of the range of goods that can be produced by the two sectors and of their degree of substitutability. First, the same fruit and/or vegetable that is sold by a vendor on the street is the one that is found on the supermarket. Similarly, in the case of electronics, developing countries have malls that sell TV’s, DVD players, Playstations etc. at lower prices and it is well known that this is because they do not pay any taxes on them, but it is exactly the same product that one would find at a Sony or Apple Store.\(^{14}\) The substitution elasticity between formal and informal goods is very high.

In terms of comparing the benchmark substitution elasticity that I use to others, Benhabib et al.\(^{14}\) These malls are known by different names across countries (cities). A few examples in Mexico City are “Tepito” and “Plaza Meave”, in Perú (Lima) the largest one is called “Polvos Azules”, in Agentina (Buenos Aires) “Galería Jardín”, in Colombia (Bogotá) “San Andresito”, and in Colombia (Medellín) “El Hueco”, to name a few.

Usually they also sell CD’s, DVD’s, designer clothes and other imported goods. Most of the merchandise is original, but they sell it at lower prices because they don’t pay any import or sales taxes on it (making it contraband). Nevertheless, it comes with a factory warranty. With a small part of the merchandise one can tell that it is not original but a very close replica. This can be the case of CD’s, DVD’s or clothes; when they are not the originals they are sold at extremely low prices.

Although the prices at these malls are always cheaper than in the formal stores, there are several reasons why not everyone shops there and they would rather go to formal stores. These malls are usually located in unsafe, low-income areas of the city, so people often prefer the formal stores in order to avoid the hassle of going there, both because of the commuting and personal safety. At the same time those that live close by or are not threatened by the area may prefer going to a formal store in order to have access to credit.
(1991) fix the consumption elasticity equal to 5. This is lower because in the household production literature they are talking about the elasticity of substitution between consumption goods produced by market and non-market activities. A dinner cooked by a professional gourmet chef in a restaurant is not the same as one cooked by someone at home, and the results of dry cleaning are in general impossible to attain at home with a standard washing machine. On the contrary, I’m talking about literally the same good.

In order to fix the consumption elasticity to 5, Benhabib et al. (1991), take an average over an estimation done by Eichenbaum and Hansen (1990) and themselves. Eichenbaum and Hansen use aggregate data to estimate a model where the degree of substitution is between market consumption goods and the flow of services from consumer durables. Benhabib et al. argue that consumer durables can be thought of as the output of home production when the only input are durable goods. Eichenbaum and Hansen conclude that there is “very little evidence against the hypothesis that the services from durable and non-durable goods are perfect substitutes”. This statement implies \( e = 1 \). Benhabib et al. find \( e = 0.6 \), but they consider their estimate to be highly preliminary. The argument used by Benhabib et al. to use the estimated value of \( e \) by Eichenbaum and Hansen is directly applicable to my case, so given this estimate and the available evidence of the nature of informal production mentioned before, it’s plausible that the substitution elasticity between formal and informal consumption goods is higher than in the home production literature.

Finally, the parameters \( a \) and \( b \) are chosen such that in steady state \( h^f + h^i = h^t = 0.33 \), and the share of informal labor can be fixed as desired. It turns out that these parameters are important only in the steady state but they don’t really affect the volatility of the model. Table 2 shows a summary of the benchmark parameter values as well as the ranges used in the sensitivity analysis.

To solve the model, I log-linearize around the steady state, find the state space representation, and simulate the model. The length of the simulation is set to 1000 (after adjusting for initial value dependence). All the series are detrended using the Hodrick and Prescott filter with a smoothing parameter of 1600 before computing any statistics. I calculate the relative volatility of consumption to output by calculating the ratio of the standard deviation of the two simulated variables. The
Table 2: This table shows the range of values used for the sensitivity analysis for each parameter, as well as its benchmark value (bold letters).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range and Benchmark Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta$</td>
<td>0.3, 0.2, 0.1</td>
</tr>
<tr>
<td>$1 - \epsilon$</td>
<td>20, 12, 8, 4, 2</td>
</tr>
<tr>
<td>$1 - \nu$</td>
<td>2, 0.5, 0.1</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Decreases as the size of Informal Sector Increases</td>
</tr>
<tr>
<td>$a$ and $b$</td>
<td>Chosen such that $h^f + h^i = 0.33$ and to fix $\frac{h^i}{h^f}$ in steady state</td>
</tr>
<tr>
<td>$\rho_f$, $\rho_i$</td>
<td>$\rho_f = \rho_i = 0.95$, $\rho_f = 0.95$, $\rho_i = 0.7$</td>
</tr>
<tr>
<td>$\sigma(\epsilon^f)$, $\sigma(\epsilon^i)$</td>
<td>0.007</td>
</tr>
<tr>
<td>$\rho(\epsilon^f, \epsilon^i)$</td>
<td>0.66, 0, -0.66</td>
</tr>
</tbody>
</table>

The realization of the shocks is the same in every simulation (the seed of the random generator is fixed), so the volatility is fully comparable between different sizes of the informal sector.

I calculate the relative volatility of consumption to output for four different sizes of the informal economy. Namely, the time devoted to work in the informal sector is 10%, 30%, 50% and 60% of the total amount of steady-state time devoted to work in market activities (8 hours a day).

5 Results

5.1 Benchmark Model and Calibration

Figures (2) to (7) show the results of the different experiments. Figure (2) shows the results for the benchmark model and calibration. The solid blue line in the graph is the relative volatility of consumption to output when only the formal terms are measured, $\sigma(c^f)/\sigma(y^f)$. From now on I’ll refer to this as Formal Relative Volatility. The solid grey line is the relative volatility of consumption to output when both the formal and informal terms are measured, $\sigma(c^T)/\sigma(y^T)$. I’ll refer to this as Total Relative Volatility.\(^{15}\)

The main mechanism driving the results of the model, just as in the home production literature, relies on the fact that when individuals are able to substitute between formal and informal

\(^{15}\)Where $c^T = c^f + pc^i$ and $p$ is the steady state value for the relative price of informal to formal goods.
consumption goods over time, volatility arises due to absolute productivity shocks as well as relative productivity differentials between the formal and the informal sector. When the productivity of the formal sector is high relative to informal productivity, agents substitute informal for formal consumption, producing a higher volatility (when only formal consumption is measured) than that generated by the standard one-sector model. Furthermore, we observe that formal relative volatility increases with the size of the informal sector because the magnitude (relative to steady state levels) of the response of the formal sector to changes in relative productivity has to be greater when its size is smaller in order to generate the desired changes in consumption.

Furthermore, we know that in the standard one sector model output is more volatile than consumption. Nevertheless, note that when the share of informal labor is sufficiently large (when the informal sector is roughly greater than 30% of GDP)\textsuperscript{16}, in this model consumption is more volatile than output. This is because consumption goods have a higher elasticity of substitution than investment goods. As a result, the reallocation of consumption from the informal to the formal sector or vice versa, in response to a relative productivity shock, is greater than that of investment. The volatility of formal output can be lower than that of formal consumption because investment is not reallocated as much as consumption due to the investment complementarity.

If we measure total consumption what we observe is different. As formal and informal consumption goods are substitutes and hence are negatively correlated, when we calculate total consumption, the volatility of the two goods cancels out resulting in a lower volatility of total consumption, and hence a lower total relative volatility.

The results show that a country’s reported relative volatility of consumption to output can be somewhere between 0.5 and 3.7 times as high as the true value depending on the size of the informal economy and whether informal output is measured or not. This implies a presumption that the relative volatility of consumption to output will be higher in countries with large informal sectors that are not well measured.

\textsuperscript{16}Note that the horizontal axes on the graphs is in terms of the share of informal labor. It is not informal output as a percentage of total output, but, a share of informal labor of around 50% corresponds to an informal sector that is around 30% of the total economy.
Figure 2: Relative volatility of consumption to output when just the formal sector is measured and when total consumption and GDP are measured, using the benchmark calibration of Table 2.

5.1.1 Sensitivity to Investment Elasticity

Figure (3) shows the effect that the elasticity of substitution of investment goods has on the formal relative volatility. Total relative volatility was omitted from the graph because it doesn’t change significantly when the elasticity of investment changes.

While investment goods are complements, the resulting formal relative volatility of consumption to output is very similar to the benchmark (given by the dotted and solid lines, respectively). As investment goods turn from complements to substitutes, the formal relative volatility declines, and, more importantly, consumption is always less volatile than output. When both consumption and investment are substitutable between sectors, so is output. As a result, output is as volatile or more than consumption.
5.1.2 Sensitivity to Intratemporal Elasticity of Substitution of Consumption Goods

The assumption that formal and informal consumption goods are substitutes is important. Table (3) shows the changes in the relative volatility of consumption to output as the elasticity of substitution of consumption goods decreases for the different shares of informal labor when the informal sector is measured and when its not measured at all.

Notice that even for an elasticity of substitution of two, it is the case that economies that have a large informal sector and measure it poorly report a higher relative volatility of consumption to output. However, as in the home production literature the quantitative results do depend on the value of this parameter. This is because as the elasticity of substitution of consumption goods increases, the wealth effect is reduced causing the elasticity of labor supply to increase. This
generates, given a certain technology shock, a higher volatility of hours worked and output, (see Benhabib et al. (1991)). For example, for an elasticity of substitution of twenty, we would be able to explain the majority of the relative volatility of most countries with just the existence of an unmeasured informal sector. Furthermore, notice that two is clearly below the value used in home production and highly implausible for the very similar goods traded in the formal and informal sector.

Table 3: Formal and total relative volatility of consumption to output as the elasticity of substitution between formal and informal consumption goods decreases.

<table>
<thead>
<tr>
<th>Share of Informal Labor</th>
<th>Measure</th>
<th>Elasticity of Substitution of Consumption Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>10%</td>
<td>Formal</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.25</td>
</tr>
<tr>
<td>30%</td>
<td>Formal</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.42</td>
</tr>
<tr>
<td>50%</td>
<td>Formal</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.44</td>
</tr>
<tr>
<td>60%</td>
<td>Formal</td>
<td>1.39</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.46</td>
</tr>
</tbody>
</table>

5.1.3 Sensitivity to Correlation of Productivity Shocks

Figure (4) shows what happens when the productivity shocks don’t have a positive correlation. As the correlation tends to -1 the difference between the formal and the total relative volatility of consumption to output decreases. The fact that countries with a large informal economy have a higher relative volatility still holds. The main difference is that the gap between the formal and total relative volatility is now smaller, and countries with an informal economy that accounts for about 18% or less of GDP are going to report a relative volatility of consumption to output below one regardless of their ability to measure the informal economy while countries with an informal economy that is above 18% of GDP are going to report a relative volatility above one if the informal sector is poorly measured and below one if it is properly accounted for. Smaller
Figure 4: Relative volatility of consumption to output when just the formal sector is measured (black lines) and when total consumption and GDP are measured (grey lines). The solid lines correspond to the benchmark case, the dashed lines to zero correlation and the dotted lines to a correlation of -0.66.

correlations generate higher relative volatility.

5.1.4 Sensitivity to Capital Intensity in the Informal Sector

According to Thomas (1992), production is more capital-intensive in the formal economy. The capital intensity of the formal sector is $\alpha = 0.36$, and in my previous results I fixed the capital intensity of the informal sector to $\theta = 0.2$. Figure (5) shows what happens if the capital intensity of the informal sector is fixed to $\theta = 0.3$ and $\theta = 0.1$. Notice that there is not an important qualitative difference in the results but only a slight difference in terms of the level of the relative volatility. A higher capital intensity delivers a higher relative volatility and a low capital intensity delivers a lower relative volatility. This is expected because, given that consumption goods are substitutes,
Figure 5: Relative volatility of consumption to output when just the formal sector is measured (black lines) and when total consumption and GDP are measured (grey lines). The solid lines correspond to the benchmark case, the dashed lines to $\theta = 0.3$ and the dotted lines to $\theta = 0.1$.

when the informal sector is more capital intensive it has more capacity of production and hence there is more room to substitute formal for informal consumption goods which raises the volatility of formal consumption. The opposite is true when the capital intensity goes down.

5.2 Special Cases

In this subsection I run the same experiment as before, but for two special cases of the model. First, I shut down the production of informal investment goods, hence in this case all investment goods come from the formal sector. In my second special case, once the capital is in one sector it can’t be reallocated. The idea is to see how different the results are in the absence informal investment goods, and how important a feature like imperfect capital mobility would be.
5.2.1 No Informal Investment

The setup of the model without informal investment is the same as the benchmark setup with the difference that informal firms do not produce investment goods and there is no investment firm that produces a compound investment good. Hence, households purchase investment goods directly from the formal firm. The new market clearing conditions are then

\[
\begin{align*}
  h^f_t &= l^f_t, \\
  h^i_t &= l^i_t, \\
  k^f_t + k^i_t &= k_t,
\end{align*}
\]

\[
\begin{align*}
  A^f_t (k^f_t)^\alpha (h^f_t)^{(1-\alpha)} &= c^f_t + x_t + g_t, \\
  A^i_t (k^i_t)^\theta (h^i_t)^{(1-\theta)} &= c^i_t.
\end{align*}
\]

Figure (6) shows the results for this case. They are different from those of the benchmark model in a number of ways. First, the formal relative volatility is flatter than the benchmark. Here the model does not generate a relative volatility greater than one for any size of the informal sector. Second, the total relative volatility is higher than before. Third, the difference between the formal and the total relative volatility is smaller. The fact that the informal sector produces investment goods is important in terms of the difference between the reported and true relative volatility of consumption to output. The production of informal investment goods generates higher volatility of formal consumption.
Figure 6: Relative volatility of consumption to output when just the formal sector is measured (black lines) and when the total consumption and GDP are measured (grey lines). There is no informal investment and capital is perfectly mobile between sectors (dashed lines). The solid lines are the benchmark case.
5.2.2 No Informal Investment and Imperfect Capital Mobility

If apart from shutting down informal investment I restrict capital mobility, the difference in the setup is that the rental rate of capital in the two sectors is going to be different and households choose \( k_f \) and \( k_i \) independently. So the maximization problem of the households is now

\[
\max_{\{c_f, c_i, l_f, l_i, x_f, x_i\}} \quad E_t \left( \sum_{t=0}^{\infty} \beta^t u(c^f_t, c^i_t, l^f_t, l^i_t) \right)
\]

subject to

\[
(1 - \tau)w_f l_f + w_i l_i + r_f k_f + r_i k_i = c_f + p_x c_i + x_f + x_i,
\]

\[
x_f^t = k_{f,t+1}^t - (1 - \delta)k_f^t,
\]

\[
x_i^t = k_{i,t+1}^t - (1 - \delta)k_i^t,
\]

\[
x_f^t \geq 0, x_i^t \geq 0,
\]

and the market clearing conditions are given by

\[
k_f^t = K_f^t,
\]

\[
k_i^t = K_i^t,
\]

\[
h_f^t = l_f^t,
\]

\[
h_i^t = l_i^t,
\]

\[
A^f_t (k_f^t)^{\alpha} (h_f^t)^{(1-\alpha)} = c_f^t + x_f^t + x_i^t + g_t,
\]
\[ A_t^i (k_t^i)^\theta (h_t^i)^{(1-\theta)} = c_t^i. \]

Figure (7) shows the results for this alternative setup. They are very similar to those of the previous case where capital is perfectly mobile, but the volatility goes up by a little bit. Having imperfect capital mobility doesn’t have an important effect on the relative volatility of consumption to output.

Figure 7: Relative volatility of consumption to output when just the formal sector is measured (black lines) and when total consumption and GDP are measured (grey lines). There is no informal investment and there is imperfect capital mobility between the formal and informal sector (dashed lines). The solid lines are the benchmark case.
6 Final Remarks

This paper has documented a systematic cross-country relationship between the relative volatility of cyclical consumption to output and the size of the informal sector. Specifically, I found that countries that have a higher cyclical volatility of consumption relative to output have large informal sectors.

To understand this relationship, I constructed a model economy in which there are two sectors, a formal sector which is measured and an informal sector which is not measured. The model shows that relatively high consumption volatility is a natural consequence of having a large and poorly measured informal sector. The main factor driving the high volatility is that formal and informal consumption goods are substitutes. The ability of individuals to substitute between formal and informal consumption goods, both over time and within the same period, implies that absolute productivity shocks as well as relative productivity differentials between the formal and the informal sector generate volatility. Furthermore, I show that when formal and informal investment goods are relative complements, consumption can be more volatile than output. This gives rise to the observation that the relative volatility of consumption to output is greater than one in countries with large unmeasured informal sectors.

This “informal sector” channel is thus a mechanism driving high consumption volatility which is complementary to other mechanisms in the literature, such as country risk that is affected by fundamental shocks and the presence of working capital and shocks to trend growth.

Interestingly, the model can rationalize high observed volatility of measured consumption relative to output in both developing countries and some developed countries that have a large informal economy. My results imply that studies of business cycles in developing countries should recognize the importance of the informal sector and how that mis-measurement can affect measured cyclical fluctuations.
Appendix

1. Taxonomy of the Informal Economy

Table 4: A Taxonomy of Informal (underground) Economic Activities

<table>
<thead>
<tr>
<th>Illegal Activities</th>
<th>Monetary Transactions</th>
<th>Nonmonetary Transactions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trade in stolen goods; drug dealing and manufacturing; prostitution; gambling; smuggling and fraud.</td>
<td>Barter: drugs, stolen goods, smuggling, etc. Produce or growing drugs for own use. Theft for own use.</td>
</tr>
<tr>
<td>Legal Activities</td>
<td>Tax Evasion Unreported income from self-employment; Wages, salaries and assets from unreported work related to legal services and goods</td>
<td>Tax Evasion Employee discounts, fringe benefits</td>
</tr>
</tbody>
</table>

Source: Rolf Minus and Roger S. Smith 1997, with some remarks added by Schneider and ErZe 2000
2. Estimating the size of the Informal Economy

There are two methods which are the most commonly used to measure the size of the informal economy. These are the Direct Approaches and the Indirect Approaches (Schneider and Enste (2000)). Here I will briefly present what each method consists of and how it could be applied.

**Direct Approaches**

This is a method that relies on surveys, samples based on voluntary replies, tax auditing and other compliance methods. The problem with this approach is that the results are going to depend directly on the questions asked by the survey. Therefore it is usually the case that the surveys made in every country (i.e. the Household Surveys) contain different questions, so it is very difficult to try to measure the informal economy of different countries using the same parameters.

Usually what ends up happening is that the definition used has to be very simple and contain only one parameter. For example, the informal sector may be defined as those people who do not have the right for a pension when they are old, but clearly this definition excludes several important elements that would describe the informal economy otherwise. The other very common definition is that a person is considered to work in the informal economy if they work for a firm that has \( N \) or fewer workers. This is a very strong assumption because a firm can be very small but still comply with the law and its production can be reported to the authorities, meaning that its value added will appear in the GDP no matter how small it is.

On the other hand, if what is used is a direct questionnaire, people are not usually willing to admit that they are not reporting taxes or that they are having a fraudulent behavior, either because they feel afraid of getting caught or because they feel ashamed because they know that this is a moral issue. This makes it difficult to estimate the extent of undeclared work. The advantages and disadvantages of this method are discussed in great detail by Mogensen et al. (1995).

Finally, a direct estimate of the informal economy can also be obtained by calculating the discrepancy between income declared for tax purposes and that measured by selective checks.
This method has been used by the IRS (1979) and IRS (1983) in the United States, Simon and Witte (1982), Witte (1987), Clotfelter (1983) and Feige (1986). Good discussions can be found in Dallago (1990) and Thomas (1992).

**Indirect Approaches**

These are macroeconomic approaches, known as indicator approaches. Here are some of them.

**Discrepancy between the National Expenditure and Income Statistics**  In theory, the income measure of the GDP and the expenditure measure should be equal to each other. But informal activities will show up in the expenditure measurement but not in the income measurement. Thus, the difference between these two measures is an indicator of the size of the informal economy. The problem with this estimate is that the statisticians would like to make the difference between the two as small as possible, so it would be ideal to take the initial measure and not the published measure. Then, apart from this issue, we have also the differences due to sampling and statistical error which can not be disentangled from the amount that can be explained by the informal economy.

**Discrepancy between Official and Actual Labor Force**  Assuming that the total labor force participation is constant, ceteris paribus, then any decrease in the labor force participation in the official economy can be seen as an indicator of an increase in the activity in the informal economy. The problem with this method is that changes in the labor force participation can be due to other causes. Also it could be the case that people work in both the informal and formal economy, so this is not a very good estimator.

**The Transactions Approach**  Feige (1979) developed this approach. This approach is based on the quantitative theory of money $MV = pT$ where $M$ is money, $V$ is velocity, $p$ are prices, and $T$ total transactions. The main assumption is that the relation over time of the volume of transactions and official GNP is constant. He uses the value of total transactions ($pT$) as an estimate of nominal
GNP, and, then, the informal economy is the difference between nominal GNP and the official GNP. The problem is that he has to assume a base year where the assumption is that there is no informal economy. Also, the assumption that the ratio of transactions to official GNP is constant over time is quiet strong. Additionally, obtaining accurate estimates of the total number of transactions is difficult.

The Currency Demand Approach  This approach was first proposed by Cagan (1958) and then Tanzi (1980) and Tanzi (1983) took the method a step further. The main idea is that they want to see the correlation between currency demand and tax pressure. The main assumption is that informal activities operate with cash. Thus, if the tax burden increases and so does the demand for money then that increase in the demand for money reflects an increase in the informal economy.

In order to calculate the excess in money demand, they estimate an equation for money demand using econometric methods. They control for development of income, payment habits, interest rates, and other related variables. In the equation they also include government regulation, direct and indirect tax burden, and the complexity of the tax system.

The most common critiques to this approach are the following: Not all the transactions in the shadow economy are paid in cash. Most studies using this approach include only the tax burden factor and ignore others such as “tax morality”, regulation and attitudes towards the state (there is usually no reliable data on these factors). A rise in currency demand deposits is usually due in large degree to a slowdown in demand deposits and not in a rise in currency due to informal economic activity. Also, most studies assume that both the formal and informal economy have the same velocity of money.

The Physical Input (Electricity Consumption) Method  Here I will present the Kaufmann-Kaliberda Method. Kaufmann and Kaliberda (1996) assume that electricity consumption is the best physical indicator of both formal and informal economic activity. It has been observed that the electricity/GDP elasticity is usually close to one. So, by using electricity as a proxy for the overall
economic activity and then subtracting from it the official estimates of GDP we get an indicator of informal economic activity. The difference between the growth of electricity consumption and official GDP is then attributed to the growth of the informal economy.

The critiques to this approach rely in the fact that not all informal activities require a considerable amount of electricity, or, if they do, other energy sources as gas, oil, coal etc. could be used. Also, the use of electricity has become more and more efficient in both types of economies. Finally, there may be differences in the elasticity of electricity/GDP across countries or changes over time.

3. Sensitivity Analysis to Persistence of Informal Productivity Shock

Figure 8: Relative volatility of consumption to output when just the formal sector is measured (black lines) and when total consumption and GDP are measured (grey lines). The solid lines correspond to the benchmark case and the dashed lines are the case when the autorregresive parameter of the informal shock is 0.7.
References


