Labor Informality and Business Cycles in Emerging Economies

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First Draft - July 2013

Abstract

We first document labor dynamics across emerging and developed economies over the business cycle and argue that some of the differences across these types of economies are linked to the large informal labor markets in emerging economies. This is later explored in depth for the case of the Mexican economy, for which we construct several alternative time series of informal labor at business cycle frequencies. A key stylized fact from this data is the strong countercyclicality of informal labor. We then build an equilibrium business cycle model of a small, open economy that incorporates formal and informal labor markets, and that is perturbed by stationary and trend shocks to total factor productivity. The model is calibrated to match, among other things, the large productivity gap observed between formal and informal firms in Mexico as well as the average share of informal labor. It can account for the sharp countercyclicality of informal labor, in addition to other salient stylized facts of Mexican business cycles such as the large volatility of consumption, and the countercyclicality of the trade balance. While we find that trend shocks are relatively more important than stationary ones, a result obtained by Aguiar and Gopinath (2007), the size of these shocks is roughly one third of what was estimated in this earlier work. This comes from the fact that informal labor markets act as a propagation mechanism for these shocks, to the extent that these are imperfectly transmitted from the formal to the informal sector.

Keywords: Emerging economies, business cycles, informal labor, consumption volatility
JEL codes: F41, F44

¹We benefited from conversations with Gita Gopinath, Adam Gulen, Norman Loayza, P. Andrés Neumeyer, Martín Uribe and Carlos Urrutia. We also thank the comments by Gianluca Violante and three anonymous referees. Juan David Herreno and Rodolfo E. Oviedo-Moguel provided excellent research assistance. All errors and omissions are our own. The information and opinions presented are entirely those of the author(s), and no endorsement by the Inter-American Development Bank, its Board of Executive Directors, or the countries they represent is expressed or implied. Felipe Meza thanks the Asociacion Mexicana de Cultura A.C., and CONACYT (via research grant No. 81825) for financial support. Emails: andresf@iadb.org, felipe.meza@itam.mx.
1 Introduction

There is an increasing literature on the sources of business cycles in emerging market economies (EME)\(^2\). A key lesson coming out of this literature is that frictions matter when propagating traditional technology or interest rate shocks. Such frictions can either be broadly recovered as permanent shifts to total factor productivity (TFP) or, more narrowly, be associated to financial frictions that amplify interest rate shocks. However, an important observation to be made on this literature is that it has largely abstracted from labor market frictions. Moreover, even lesser attention has been given to labor informality, despite the fact that informal labor markets are often a distinctive characteristic of EME\(^3\). In Latin America, for instance, recent estimates have found that, on average, one out of every two workers is employed through the informal labor market\(^4\).

These observations raise both empirical as well as theoretical questions. On the empirical side, does informal labor exhibit any distinctive pattern across the business cycle of EME? If so, is it relevant in shaping the dynamics of aggregate labor? Are those dynamics different from advanced economies? On the theoretical side, how should the current framework for studying aggregate fluctuations in EME be modified to account for the large share of informal labor in these economies, and for its business cycle properties? Does this modification change our understanding of the driving forces behind business cycles in these economies?

This paper provides answers to these questions. The strategy we use for doing so follows two steps. First, we document the link between labor informality and business cycles across emerging and developed economies with the scarce cross country data available. Then we zoom in on the case of Mexico for which much more available data exist. We use it

\(^2\)See the works by Neumeyer and Perri (2005), Uribe and Yue (2006), Aguiar and Gopinath (2007), Mendoza (2010), Garcia-Cicco et.al. (2010), Chang and Fernandez (2013) and Fernandez and Gulan (2013), among others. These contributions have used dynamic general equilibrium models of the business cycle.

\(^3\)Notable exceptions introducing labor market frictions in small open economies are Boz, Durdu and Li (2009), Li (2011), and Lama and Urrutia (2013). Also Restrepo-Echavarria (2011) and Finkelstein (2012) explicitly model an informal sector. See the next section for a more comprehensive literature review.

\(^4\)See IDB (2013). This study reports that the (population-weighted) average of informality across Latin American countries is 44.1 percent. Dispersion by income quintiles is also significant within countries: the bottom quintile rarely exceeds 20 percent coverage of formal employment. IDB (2013) measure informality as the percentage of employed workers in each income quintile, aged 20 and older, who are not contributing to social security.
to construct and analyze several alternative time series of informal labor at business cycle frequencies. We also document some other properties of informality in Mexico such as its link to productivity and firm size, the transition rates from formality to informality, and the issues surrounding the measurement of the informal sector in official statistics.

Guided by the stylized facts gathered from this first task, in a second step we build a business cycle model of a small open economy with both formal and informal labor markets. Households choose how much labor to allocate to each market. They accumulate two different capital stocks, which are specific to formal and informal sectors, and consume formal and informal goods produced in each sector. Formal capital is rented to firms, while informal capital is used in the informal sector. Households can buy or sell one period non-contingent bonds in foreign capital markets. Production in the formal sector is done by firms. In the informal sector people are self-employed given the tight link between informality and self-employment that we document for Mexico. Both technologies have constant returns to scale and use capital and labor in production. Formality entails costs and benefits. The formal firm has to pay taxes on the wage bill but enjoys high productivity levels. The informal producer is less productive but does not pay taxes. The productivity gap is motivated by the evidence we report in terms of the large TFP differentials across formal and informal firms in Mexico. Technology in the formal sector faces two shocks. As in Aguiar and Gopinath (2007), AG henceforth, there are transient productivity shocks and shocks to the growth rate of labor-augmenting productivity. These shocks in the formal sector are passed-through to the informal sector. We consider various degrees of transmission of these shocks across the two sectors. This is a reduced-form device to capture institutional or other types of barriers that prevent business cycle drivers to fully spread across labor markets. Finally, the government taxes personal income (wages and capital rents) and the hiring or labor by formal firms to finance a stream of government purchases.

The main results can also be categorized in two parts. On the empirical side, the first finding is that informality, proxied using annual data on self-employment, is a distinctive characteristic that distinguishes EMEs from developed economies. This distinctive pattern comes from the fact that informality is negatively correlated with income levels both across and within the two groups of countries. This is also robust to proxies of informality different
from self-employment within a pool of EME. Second, when comparing employment dynamics across EME and developed economies we find some similarities but also some important differences which can be linked to informality. Volatility of cyclical employment, relative to that of output, is lower in EMEs when compared to developed economies. Aggregate labor is less procyclical in EMEs, but the difference is not statistically significant. However, within the group of EME, we do find a statistically significant negative correlation between labor procyclicality and labor informality. These results are reinforced when we zoom in on the case of Mexico. Informal labor in Mexico, proxied with self-employment or any of the other four measures we build, is unambiguously countercyclical and lags the cycle. This distinctive pattern explains why total employment in Mexico is less volatile and procyclical when compared to a developed small open economy like Canada. Finally, we document how informality in Mexico is mainly a phenomenon of small and unproductive firms; that there is a very active transition across formal and informal labor markets; and that the size of the informal sector is highly underestimated in the national accounts and has continued growing over time.

The model that we build also allows us to derive important theoretical results. First, model-based simulations reveal that the degree of transmission of shocks across sectors is crucial when explaining the dynamics of the model. Relatively low levels of pass-through of shocks from the formal to the informal sector translate into stronger volatility in the informal labor market which, in turn, impacts the volatility of formal output. This generates the incentives for workers to relocate from one sector to the other with real effects in economic activity. A positive TFP shock, for example, will not perfectly pass-through into the informal sector, thereby providing the incentives for people to move out of the informal sector. Hence a first important finding is that the presence of an informal sector coupled with imperfect pass-through of shocks across sectors constitutes a powerful amplifying mechanism for shocks in emerging economies. This is further illustrated when we take the model to Mexican data. We calibrate the model to match, among other things, the large productivity gap observed between formal and informal firms in Mexico as well as the average share of informal labor. A small subset of the parameters, those governing the degree of pass-through of shocks and their standard deviation, are calibrated to match some dimension of the data. The model
matches the data fairly well. It accounts for the relatively low variance and procyclicality of total employment, the countercyclicality of informal labor, and other salient stylized facts of Mexican business cycles such as the large volatility of consumption, and the countercyclicality of the trade balance. However, it underpredicts the volatility of informal labor. As in AG, trend shocks to the TFP are more important than transitory ones. Yet the calibrated standard deviation of these shocks is between $1/3$ to $1/4$ of what was estimated by AG on the same Mexican data. This reiterates the results that informal labor markets act as an important propagation mechanism for these shocks, to the extent that they are imperfectly transmitted across sectors.

Some of the simplifying assumptions of our benchmark framework are relaxed in further extensions to our model. Specifically we consider the inclusion of capital adjustment costs in both sectors; we explicitly model an imperfect measurement of informal economic activity in the model's main macro variables; and we allow for the pass-through of shocks from the formal to the informal sector to differ across the two types of shocks that we consider. The results are largely robust to these modifications.

Despite exploring these extensions, our model continues to abstract from interesting issues. For example, we do not model unemployment. Nor do we explicitly consider the presence of downward nominal wage rigidities or non-linearities in the choice of hours. Yet the extremely low historical levels of Mexican unemployment, around 3 percent, are an indirect measure of the relevance of the informal labor market. Likewise, arguably, such rigidities and non-linearities are more acute in the formal sector which would make the assymetric response to shocks across sectors more acute. Something we are already capturing in our model, albeit in reduced form. In sum, we believe that adding such realistic features to our theoretical framework would further reinforce the main message of the paper: that informal labor markets matter for EME’s business cycles.

The rest of the paper is divided into eight sections including this introduction. In Section 2 we present a brief review of the literature that has modeled labor markets in EME with a dynamic equilibrium framework. Section 3 presents the stylized facts. The model and its calibration are explained in Sections 4 and 5, respectively. Section 6 presents our benchmark quantitative results. Section 7 reports robustness analysis. Finally, some concluding remarks
are given in Section 8. Further technical details are gathered in a companion appendix.

2 Related research

In this section we review some of the recent research on labor markets in EME’s business cycles. Particular attention is given to the works that have analyzed informal labor markets. We finish by discussing the contribution of our paper to this line of research.

There are few papers that study the labor market in business cycle models of small open emerging economies. Neumeyer and Perri (2005) report statistics for employment and hours across emerging and developed countries. In their sample, both employment and hours are less volatile in emerging that in developed countries. Additionally, both employment and hours are less positively correlated with output in emerging than in developed countries. When analyzing the predictions of their model, in which a working capital requirement interacting with interest rates plays a central role, they find that predicted hours are more volatile and more correlated with output than actual hours for Argentina. They explain this by arguing that government employment is used as unemployment insurance in Argentina. Fernandez and Meza (2011) investigated whether this also holds in Mexico by studying the cyclical dynamics of total employment with and without public employment. They found that there was basically no difference in business cycle statistics. Therefore, for the case of Mexico, they did not find evidence that the presence of government employment explained the low volatility and correlation of total employment.

Boz, Daude and Durdu (2011) explore the predictions of the model in AG when agents imperfectly distinguish and learn about the permanent and transitory components of productivity. They calculate impulse-response functions for the perfect information version of their model, which is equivalent to AG, and report that a positive growth shock produces a fall in labor. They also report that introducing learning about the trend reduces the size of the problem, but does not eliminate it. The impulse-response function of their model with imperfect information yields smaller falls in labor after a growth shock. Therefore, a positive growth shock continues to produce a drop in labor. They do not report the predicted correlation between labor and output in the imperfect information case. In relation to this,
Fernandez and Meza (2011) showed that the model in AG can produce a positive correlation between labor and output under certain conditions.

Boz, Durdu and Li (2012) report business cycle statistics for labor in a set of emerging and developed economies. They find that labor in emerging markets is more volatile than in developed markets, and the difference is statistically significant. Also, they find that labor is less procyclical in emerging markets, although the difference is not statistically significant. In terms of modeling, they embed search-matching frictions of the Mortensen-Pissarides type in the labor market of a small open economy. In their benchmark model the volatility of unemployment is much lower than the one in the data. They analyze the effect of adding to their model procyclical shocks in the technical efficiency at which matches are generated. They calibrate the persistence and volatility of these shocks to match the volatility of unemployment and its correlation with output, and look at further implications. The predicted autocorrelation of unemployment increases relative to the benchmark but is still away from the observed value.

Li (2011) documents that real wages are about twice as volatile in emerging markets compared with developed economies. She builds a small open economy that can account for the high volatility of wages in emerging economies. The model focuses on a propagation mechanism based on exogenous interest rate shocks amplified via a working capital requirement. She reports that the predicted volatility of the labor input is higher than in the data, as in Neumeyer and Perri (2005).

There are few papers that explicitly model informality in a dynamic, general equilibrium framework. To the best of our knowledge, the first one is Conesa, Diaz-Moreno and Galdon-Sanchez (2002). They focus on explaining the negative relation between participation rates and the volatility of GDP observed in Summers-Heston data. They present a dynamic, stochastic closed economy model where labor is assumed to be indivisible in the formal sector, whereas it is divisible in the informal sector (they call it the "underground economy"). Production in the formal sector is affected by a total factor productivity shock. In the case of the informal sector there are no productivity shocks. Parameters determining the stochastic productivity process in the formal sector are chosen to match the properties of the Solow residual in the U.S. There is a unique consumption and investment good, which
can be produced in both sectors. All markets are competitive. There is no government and therefore no taxation.

On the issue of the effect of taxation on informality, Ihrig and Moe (2004) measure the effect of taxation on the size of informal employment. They model a dynamic, deterministic, closed economy. In their model the consumer can operate two technologies, a formal and an informal one. There are constant returns to scale in the formal sector, and decreasing returns to scale in the informal one, which uses only labor. They make this assumption because they want to model the shrinking of the informal sector as the economy grows. There is a unique consumption and investment good, which can be produced in both sectors, as in Conesa et al. (2002). All markets are competitive. Importantly, formal output is taxed, whereas informal output is taxed only with a certain probability. They calibrate the tax rate with the lowest marginal statutory rate for Sri Lanka. They set the probability of paying taxes to zero, given the lack of direct measures of enforcement. They report policy experiments in the steady state, in which they vary either the tax rate or the detection probability.

Fiess, Fugazza and Maloney (2010) focus on accounting for the cyclical behavior of informal self-employment. They present a dynamic, deterministic, two-sector model of a small open economy. There is a salaried sector which produces a tradable good. The self-employed sector produces a non-tradable good. Both sectors use capital and labor. The non-tradable good is only used for consumption. There is no government and no taxation. To enter the self-employed sector, the entrepreneur must pay a capital installation cost. Parameters in the model are not calibrated, the focus being the qualitative response of the economy to different shocks: productivity and demand shocks. The authors test the predictions of their model using cointegration and data for Latin American economies.

Restrepo-Echavarria (2011) aims at explaining, via the presence of an informal sector, the fact that consumption volatility is higher than output volatility in emerging countries. She presents a two-sector, dynamic and stochastic closed economy model. Formal output satisfies the demand for consumption, investment, and government spending. Informal output fulfills the demand for consumption and investment. Investment goods are transformed into aggregate investment that determines capital accumulation. Labor income from the formal sector is taxed. Labor flows freely between the two sectors. All markets are compet-
itive. Output in each sector is affected by a total factor productivity shock. Arguing that there is no evidence on the persistence of shocks in the informal sector, she assumes that the persistence is the same as in the formal one. She also assumes that shocks across sectors are correlated. Her main finding is that the relative volatility of consumption is higher if informal activity (output and consumption) is not measured as part of the total activity of the economy, i.e. if informal activity is not included in national accounts 5.

This paper contributes to this literature in two distinct ways. On one hand we provide a more systematic evidence of the business cycle properties of labor informality. We do so for a pool of EME and then focus on Mexico where the available data allows a more thorough analysis. On the other hand the model we provide is the first approach using a dynamic, stochastic, open economy model, which seems the most appropriate environment when trying to account for business cycles in emerging economies. We also discipline our model by calibrating it to key features of the Mexican formal and informal sectors. We introduce a government that taxes activities in the formal sector which is a key determinant of the size and dynamics of the informal economy. Instead of looking at statutory rates to calibrate the taxes, we use the method of Mendoza, Razin and Tesar (1994) and measure effective tax rates. Also we calibrate the productivity gap between formal and informal labor based upon firm-level data for Mexico. Finally, in terms of predictions, we report a larger set of business cycle statistics including those related to labor in both sectors. Therefore we can compare data to model predictions regarding moments of formal and informal labor, and also other moments that have received attention in the EME literature, such as the volatility of consumption and the cyclicality of the trade balance. In the next two Sections we provide the main details of the empirical and theoretical framework we use.

5 Other recent papers that study the informal sector are Castillo and Montoro (2010) and Ahmad, Ahmed, Pasha, Khan and Rehman (2012). These two papers present New Keynesian models in which an informal sector is introduced. In the case of Castillo and Montoro (2010) the model is a closed economy in which there are Mortensen-Pissarides labor market frictions and two sectors, formal and informal. Regarding Ahmad et al. (2012), they have a closed economy in which there are two sectors and in which consumers have market power when offering labor to the firm. A different kind of model is the one of Finkelstein (2013). The goal of this paper is to account for the negative correlation between the size of informal employment and the length of economic recoveries. He has a model with, among other characteristics, labor market search.
3 Empirical evidence

In this section we document the key stylized facts on the link between labor informality and business cycles. We begin by providing some international evidence across developed and emerging economies. Next we zoom in on the Mexican case where the data allows us to make a more in-depth study. These stylized facts will later serve both as guidelines and metric when building and evaluating the model presented in the next section.

3.1 Labor informality, growth and cycles. The international evidence

A well documented stylized fact in international macroeconomics is the sharp difference in the business cycle across developed and emerging market economies\(^6\). There is, however, much less evidence about the labor market dynamics across these two groups of economies. As emphasized in Section 2, there are very few studies about labor informality along the business cycle in EME, and virtually no study has systematically assessed the role of labor informality and its connection to the business cycle. Hence two unanswered questions in this literature are: Do labor dynamics, at business cycle frequencies, differ across developed and EMEs? If so, what is the link between these differences and labor informality?

Answering these questions empirically is not easy mainly because of the lack of available cross-country datasets on formal and, particularly, informal employment. We nonetheless do a first attempt to shed light on these issues by using the scarce data available. Our strategy is simple: we employ two widely used proxies of informal employment provided by the International Labor Organization (ILO) and correlate them to some of the key business cycle statistics. We do so with a pool of 23 countries, 9 of which are developed and 14 of which are emerging\(^7\).

\(^6\)One of the first studies to document this fact is Agenor et.al. (INSERT). Aguiar and Gopinath (2007) present a more comprehensive study and recently, Fernandez and Gulan (2013) extended Aguiar and Gopinath’s analysis to include the recent world financial crisis.

\(^7\)In choosing the pool of countries we follow Aguiar and Gopinath (2007). For developed economies, these are: Australia, Austria, Belgium, Netherlands, New Zealand, Norway, Portugal, Spain, and Switzerland; for EMEs, these are: Argentina, Brazil, Chile, Colombia, Ecuador, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Slovakia, Thailand and Turkey.
The first of the two proxies of informality that we use is self-employment. Of course, the latter is not a direct measure of informality per se, yet several studies have argued that it is not a bad approximation to informality in developing economies (see Loayza and Rigolini, 2006). We will present more evidence in this direction when studying the Mexican case. The second proxy that we use is a direct measure of informality computed by the ILO\(^8\). Unfortunately, this measure is computed only for a limited number of countries, and very few of them can be categorized as EME.

The first set of results is reported in Figures III.1 and III.2 where the two measures of informality are plotted against the level of income per capita. Figure III.1 compares across the two set of countries using self-employment while Figure III.2 uses ILO’s official measure of informal labor. The main message coming out of these plots is that informality is a distinctive characteristic that distinguishes EMEs from developed economies. While, on average, self-employment is only 10 percent of total employment in the latter group, it reaches up to 24 percent in the former. This distinctive pattern comes from the fact that informality is clearly negatively correlated with income levels both across and within the two groups of countries\(^9\).

The second set of results documents the cyclical properties of total employment. We focus in particular on two statistics that have traditionally being of interest in the business cycle literature: the procyclicality and relative volatility of employment. The results of this analysis are reported in Figures III.3 and III.4 where we plot, respectively, the correlation of (the cyclical components of) employment and output, and their relative standard deviations. Again, we correlate the two statistics against the informality levels and distinguish across developed and EMEs.

The two figures reveal some similarities as well as some important differences in employment dynamics across the two groups of economies. Figure III.3 shows that aggregate labor

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\(^8\)According to ILO, employment in the informal sector is defined as the total number of informal jobs, whether carried out in formal sector enterprises, informal sector enterprises, or households; including employees holding informal jobs; employers and own-account workers employed in their own informal sector enterprises; members of informal producers’ cooperatives; contributing family workers in formal or informal sector enterprises; and own-account workers engaged in the production of goods for own end use by their household.

\(^9\)Self-employment is statistically higher in EME, as the p-value for the null hypothesis of equality in means is less than 1 percent (Figure III.1).
is less procyclical in EMEs, but the difference turns out not to be statistically significant. However, within the group of EME there is a statistically significant negative correlation with the level on labor informality. Figure III.4 shows how the volatility of cyclical employment, relative to that of output, is lower in EMEs relative to developed economies, although here the level of informality does not seem to play a role in further decreasing the volatility\(^\text{10}\).

### 3.2 Informality and Business Cycles. Zooming in on the Mexican case

We now zoom in on the Mexican case, where the available data allows a more in-depth analysis of both formal and informal labor dynamics along the business cycle. Indeed, to the best of our knowledge, Mexico is the only country in the pool of EMEs studied in the previous section where long time series data on informal labor at a quarterly frequency exist.

Our starting point is the comparison of Mexican business cycle statistics with those of Canada. Such a comparison was already made in the seminal study of AG where Canada (Mexico) was taken as a representative developed (emerging) economy. In Table III.1 we report the second moments that were studied by AG (standard deviation and procyclicality of income, consumption, investment and the trade balance) but adding two more: the relative volatility of total employment and its correlation with the cycle\(^\text{11}\). The main message that comes out of this simple extension of AG is that the dynamics of labor is another important and unexplored dimension in which the business cycle patterns of these two economies differ. When compared to output’s volatility, aggregate cyclical labor is nearly half as volatile in

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\(^{10}\)The average correlation between labor and income in our pool of EME is 0.34 while that of developed economies is 0.40. Yet the difference does not turn out to be statistically significant. When only the pool of EME is considered, however, there is a statistically significant correlation with the level of informality. The slope of the fitted line in the pool of EME considered in Figure III.3 is negative (-0.03) and statistically significant. Hence a one percentage point increase of self-employment in EME is associated to a reduction in the correlation of labor and income. On the other hand, the standard deviation of total labor, relative to output, in developed and emerging economies is 0.96 and 0.56. We can statistically reject the equality in these two means. Overall, these results are in line with Boz et al. (2009) who compared labor market statistics across a set of the two groups of economies finding a lower but not statistically different degree of procyclicality of labor in emerging economies, and a lower and statistically significant volatility of labor in emerging countries.

\(^{11}\)There is a slight discrepancy with the moments reported by AG coming from the fact that our sample starts in 1987 while theirs started in 1980. We do so because 1987 is the year where labor statistics become available.
Mexico as it is in Canada. And in Mexico labor displays a correlation with the cycle of only 0.54 which is considerably lower than that of Canada, 0.90. These results are then in line with the international comparison made in the previous section in terms of EME displaying less procyclicality and volatility in aggregate labor.

The distinctive differences of Mexican labor dynamics relative to those observed in Canada are related to labor informality in Mexico. To show this, Table III.2 reports the cyclical properties of total labor in Mexico disaggregated into formal and informal employment. The dataset builds on the National Survey of Urban Employment (ENEU in Spanish) and allows us to divide total employment into four different measures of formal and informal labor over the period 1987.Q1 to 2003.Q2 (upper panel). The first measure of informal labor ($L_1^I$) refers to employment in establishments with 1 to 5 employees; the second ($L_2^I$) uses employment not covered by labor legislation benefits; the third ($L_3^I$) is employment from wage earners who do not receive benefits provided by labor legislation; and the fourth is self-employment ($L_4^I$). The end of the collection of the ENEU and the creation of a new employment survey, the National Survey of Occupation and Employment (ENOE in Spanish) led us to consider, in the panel below, the same measures for the period 2000.Q2 to 2010.Q4 (lower panel). Because new information was introduced to the dataset we are able to compute for this period a fifth measure of informal labor ($L_5^I$) as employment in economic units not distinguished to the households (in national accounts these economic units are called private unincorporated enterprises). However, the creation of the ENOE, which contained a different classification, prevents us from keeping track of $L_1^I$ and $L_3^I$. The five measures of formal employment ($L_1^F, L_2^F, L_3^F, L_4^F, L_5^F$) are simply the residual obtained after substracting each measure of informal employment from the total one. Last, the table reports simple summary statistics on (the cyclical component of) these various measures of formal/informal

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12 We are guided by the literature when constructing the five measures of informal labor. The first measure of formal employment is suggested by evidence that establishments in the informal sector are small. Amaral and Quintin (2006) report data for Argentina and further below we report evidence for Mexico from Busso et al. (2012) that points in the same direction. These works find that establishments with a small number of employees account for a significantly higher fraction of employment in the informal sector than in the formal one. The second measure is similar to one used by Pratap and Quintin (2006). Levy (2008) has also strongly favored the use of labor legislation benefits as a metric to measure labor informality. The third measure captures this but also the illegality of salaried workers not receiving salary-related benefits (see below for a discussion of this). The last two measures target self-employment which, as argued by others (Loayza and Rigolini 2006) has also been used as proxy for informality.
labor. The first three columns display absolute and relative volatilities of each measure as well as their correlation with the cycle. The fourth column reports the correlation of each measure with $L_4^T$, henceforth our benchmark proxy for informality. The last four columns assess the extent to which the procyclicality of each measure changes depending on the phase of the business cycle. The latter is computed with two methodologies. One defines an expansionary (contractionary) phase as the period between troughs (peaks) and peaks (troughs) of the HP-filtered cycle; the other simply uses INEGI’s official business cycle turning points\textsuperscript{13}.

There are several important stylized facts coming from Table III.2. The most salient one is that, unambiguously, labor informality is countercyclical. Regardless of which of the two samples is chosen, or which of the five measures one looks at, the correlation coefficient of (cyclical) informal labor with the Mexican output cycle is negative and statistically significant. Figure III.5 complements this stylized fact by providing the serial correlation between the cycle in $t$ and $L_{x,t+j}^T$, for $x = 1, 2, 3, 4$ and $j \in [-4, 4]$ using the first sample, and for $x = 1, 4, 5$ using the second sample. It shows how informal labor is not only countercyclical but it is also a lagging indicator which comes from the fact that such correlation peaks in $j > 0$. For example, if an economic expansion occurs in $t = 0$, informal labor will be below its trend and this negative comovement will be stronger in the subsequent quarters.

A third salient stylized fact is that the countercyclicality of informal labor is robust to the type of phase of the business cycle. Four out of the five measures of informality exhibit correlation coefficients in expansions that are statistically equivalent to those computed during contractions\textsuperscript{14}. This holds in both measures of the Mexican business cycle phase and across the two subsamples. Figure III.6 further illustrates this fact by plotting rolling window correlations between the cycle and, respectively, $L_4^F$ (upper two panels) and $L_4^T$ (lower two panels), on a centered window of 21 quarters. The two panels on the left present the results for the first sample while the two on the right do it for the second one. There is not a single period in either of the two samples where the correlations change sign. Throughout both samples the point estimates show that formal labor is consistently procyclical while informal labor is countercyclical. Moreover none of the two correlations exhibit a distinctive behavior

\textsuperscript{13}INEGI stands for Instituto Nacional de Estadística, Geografía e Informática, in Spanish. It is Mexico’s national statistical bureau.

\textsuperscript{14}The only exception is $L_4^T$ where the countercyclicality is stronger in expansions.
during the (shaded) periods identified as recessions.

### 3.3 Further properties of informality in Mexico

The stylized facts presented so far focus mainly on the cyclical properties of informality in developed and EMEs, with a closer look at the Mexican case. There are other stylized facts about the nature and characteristics of informality in Mexico, beyond the business cycle dimension, that other researchers have extensively analyzed and that are important to bear in mind for the purpose of modelling the dynamics of labor informality. In this section we highlight three of them: (i) informality in Mexico is mainly a phenomenon of many, very small, unproductive firms; (ii) there is a very active transition from formality to informality and vice versa; and (iii) the size of the informal sector is highly underestimated in the national accounts and has continued growing over time.

Busso et al. (2012) made a careful analysis of the empirical linkages between firm size, formality and legality status in Mexico using the Economic Censuses for 1998, 2003 and 2008, a very rich data set providing information on 3.6 million firms of all sizes in all sectors\(^{15}\). Based on the distinction between salaried and non salaried workers they constructed an informality index as the ratio of social security taxes paid on salaried workers to the remunerations of all employees (salaried and non salaried). Common examples of non-salaried workers include, more prominently, self-employed workers, but also workers in a family enterprise who share output or benefits, workers who sell door-to-door, and workers in a cooperative sharing output, among others. In addition, they also construct a legality index using the ratio of total security taxes to the wages of salaried workers. Thus, in their framework, informal firms can be legal or illegal, while illegal firms can only be informal\(^{16}\). Importantly, such categorization does not pre-judge about the link between productivity and

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\(^{15}\) The Census is conducted by INEGI. It measures economic activity taking place in private establishments with a fixed location in urban areas, and captures information on sales, value added, number of workers, types of contractual arrangements, labor remunerations, payments to the social security and value of fixed capital stock. To the best of our knowledge this is the most comprehensive economic census in all the EMEs that we have analyzed above.

\(^{16}\) In practice, Busso et al. (2012) do include two additional intermediate cases of firms: legal and semi-formal; and semi-legal and semi-formal. For simplicity, in our analysis we have grouped the first one as legal and formal, and the second one as illegal and informal. See Busso et al. (2012) for further explanations of these categories.
size of the firm (proxied by the number of workers).

Table III.3 provides descriptive statistics on the distribution by a firm’s legal and formal status across the three censuses studied by Busso et al. (2012). There are several stylized facts that stand out. First, the majority of firms are small, informal and legal. Second, legal workers are either concentrated in large formal firms or small informal ones. But there is also an important share of workers that are hired illegally by large firms. Third, despite concentrating much of the firms and workers, small informal firms contribute little to the value added generated in the Mexican economy.

The last stylized fact is a clear indication that informal firms operate with low levels of productivity. And this indeed what Busso et al. (2012) recover. In particular, they find that, after controlling for size and legal status, among legal firms, formal firms were on average 84 percent more productive than informal ones. And that there is a disproportionately large mass of firms with productivity levels below their sector average, the majority of those being informal ones. Last, they also find evidence of a strong correlation between productivity and distortions implying that more productive firms face larger distortions.

These findings are in line with previous studies on Mexico and other countries. IDB (2010), for example, compares the distribution of productivity between Mexican and US manufacturing firms and finds that the dispersion is much larger in Mexico, with most of the variance explained by a thick left tail populated by many small firms. Likewise, Leal (2010) compares the distribution of employment by firm size in Mexico and the US, concluding that the two distributions overlap if only formal employment is considered but they differ if informal firms are added, again as a result of a large left tail of mostly small and informal firms. Finally, Powell (2013) offers a more aggregate view of this issue by presenting evidence that, within a pool of Latin American economies, a 1 percentage point of the labor informality rate is correlated with about a 0.5 percentage point increase in the TFP gap with the US.

There are at least three explanations for this link between labor informality and productivity. One is the fact that a smaller firm’s size frequently imply less labor training, limited adoption of new technologies or innovation, and unexploited economies of scale or scope. Second, high job turnover and occupational choices concentrated in low-skilled, frequently self-employed jobs imply that capital accumulation is discouraged. And, third, relatively
high levels of informality combined with small firm size may reduce access to credit markets harming the firm’s potential to innovate and allocate resources efficiently (Powell 2013).

Another distinctive fact about labor informality in Mexico is that it is characterized by high transition rates in and out of informality. Maloney (1999) provides evidence that there is no significant segmentation between formal and informal labor markets, based upon the patterns of workers’ mobility between the two markets. This has been corroborated by Levy (2008) who computed the average permanence in formality of high (and low) wage workers in Mexico between 1997 and 2006, measured as enrollment in the Mexican social security agency (IMSS). A summary of Levy’s findings is presented in Table III.4. Overall, his findings indicate that high wage workers spent an average of 77 percent of their time in formality, and this number drops to 49 percent for low wage workers. Likewise, Bosch and Maloney (2008), using household survey data for Mexico and Brazil, concluded that flows between formal and informal sectors accounted for 60 to 70 percent of all the transitions. Last, they also present evidence that access to formality from the informal sector is strongly procyclical in both countries.

The last distinctive property of Mexican informality that we highlight here is the fact that it is likely very much underestimated in the official estimates. INEGI (2006) reports the contribution of the informal sector to total value added in Mexico. The share of informal value added in total value added was on average 12.4 percent between 1998 and 2003. Importantly, however, INEGI (2006) also recognizes that there is a wide array of activities that are not captured in the national accounts data. This goes in line with Schneider and Enste (2000), who used several methods to measure the size of informal activities in Mexico, among other countries, and found that it was approximately half of Mexican GDP in the early 90s. Restrepo-Echavarria (2011) argues also in that direction pointing out that the lack of reliable estimates from household surveys, due to selections and/or definitional bias and poor coverage, make accounting for the informal economy in the national accounts difficult. These factors, she argues, mean that most likely the official estimates "are missing

---

17 The selections bias comes from the fact that those in the informal sector are precisely the ones unwilling to be measured, while the definitional bias points to the fact that some surveys use narrow definitions of informality, such as per contributions to a pension fund, or the size of the firm. Poor coverage comes from the fact that surveys are mostly concentrated in urban instead of rural areas where precisely informality is likely to be more important.
a big slice of the production generated in the informal sector”.

Finally, it is worth pointing out that not only the size of the informal economy seems to have been underestimated but also it does not seem to be decreasing. As reported from the numbers above taken from Busso et al. (2012), the size of the informal sector has grown in Mexico since 1998. And this increase may actually have been stronger given that these authors also acknowledge that the economic censuses they use probably underreport the activity of half of all non-public sector workers in Mexico\footnote{Indeed, the censuses exclude economic activity in rural areas, as well as in urban areas that take place in mobile units (street vendors and the like). Both of them are places where labor informality prevails.}.

4 Model

The model has a formal and informal sector. Households choose how much labor to allocate to each sector. Guided by our previous research, we assume a GHH utility function (Greenwood, Hercowitz and Huffman 1988)\footnote{In Fernandez and Meza (2012) we have shown that a model with a Cobb-Douglas function and transitory and growth shocks as in Aguiar and Gopinath (2007) produces a negative correlation between output and labor, which is not observed in the data. We also found that using a GHH function together with estimating parameters ruling shocks using labor data produces procyclical labor. Therefore we use in this paper the GHH function.}. Continuing with the description of the model, there are two consumption goods produced in the two sectors. Households accumulate two different capital stocks, which are specific to the sectors. They choose which sector to allocate it to: Either to the formal sector renting it to firms, or to be used in the informal/self-employment sector. Households can buy or sell one period non-contingent bonds in foreign capital markets. Regarding production, in the formal sector goods are produced by firms. In the informal, people are self-employed. Both technologies have constant returns to scale and use capital and labor in production. The formal firm faces frictions that are intrinsic to formality. It pays taxes on the wage bill. At the same time, the formal firm enjoys higher initial levels of productivity compared to the informal sector. The informal self-employed producer faces a lower productivity level and does not pay taxes. The formal sector technology faces two shocks. As in Aguiar and Gopinath (2007), there are transient productivity shocks and shocks to the growth rate of labor-augmenting productivity. Technological shocks in the formal sector are imperfectly transmitted to the informal sector.
The government taxes personal income (wages and capital rents) and the hiring or labor by formal firms to finance a stream of government purchases\textsuperscript{20}.

We have imposed assumptions in our model to be able to produce business cycle statistics that we compare to data on formal and informal activities. On some dimensions our model abstracts from interesting issues. For example, we do not model unemployment. We make this choice for simplicity. It also reflects the fact that the unemployment rate is low in Mexico, the country to which we calibrate the model. Looking at data from the first quarter of 1987 to the second quarter of 2003 we find that the average rate is 3.4%, a very small number for international standards\textsuperscript{21}. We think that this small number reflects precisely what we are trying to model which is the presence of labor informality \textsuperscript{22}. Another aspect that we do not model is the effect of downward nominal wage rigidities in the formal sector. We make this choice to keep the model simple. At the same time this choice is supported by evidence that even though there are wage rigidities in Mexico, they are falling over time and that real wages have been very flexible and procyclical\textsuperscript{23}. Last we do not capture non-linearities in the choice of hours in the formal or informal sector as in Conesa et al. (2002). We think that adding this fact, as with the presence of nominal rigidities, would further reinforce the relevance of informal labor markets, which is the task we are set to do in the model.

### 4.1 The representative household

The representative household has a lifetime expected utility

\begin{equation}
U = E_0 \sum_{t=0}^{\infty} \beta^t u (C_t, h_t^I, h_t^F) = E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t - \Gamma_{t-1} (h_t^I + h_t^F)^\eta}{1 - \sigma} \right) \frac{1}{1 - \sigma} - 1
\end{equation}

\textsuperscript{20}The tax on hiring labor can be thought of as a reduced form for a contributory social insurance system. Anton, Hernandez and Levy (2011) discuss extensively on the financing of the social security system in Mexico.

\textsuperscript{21}The data come from the Encuesta Nacional de Empleo Urbano (ENEU, for its acronym in Spanish). This is a survey on employment compiled by the Mexican national statistics agency, INEGI.

\textsuperscript{22}Another reason why unemployment affects a small fraction of the active labor force is that there is no national unemployment insurance system in Mexico. There is an unemployment insurance system in Mexico City (that started in 2008), but not in other states or at the national level.

\textsuperscript{23}Castellanos, Garcia-Verdu and Kaplan (2004) find evidence of wage rigidites in Mexico, and of their reduction between 1986-1994 and 1994-2001. They argue that the reduction in rigidities is consistent with a decline in indexation, as inflation in Mexico has fallen continuously, and a decline in unionization. Li (2011) shows that EME, and Mexico included, are characterized by high volatility and procyclicality of real wages.
where $C_t$ is a CES aggregator of the formal and informal consumption goods $C^F_t$ and $C^I_t$, respectively:

$$C_t = \left( a(C^F_t)^e + (1 - a)(C^I_t)^e \right)^{1/e}.$$ 

As mentioned earlier, we use a GHH utility function. $\Gamma^F_{t-1}$ is (trending) labor productivity in the formal sector. We include it in the utility to achieve a balanced growth path. Labor in the formal and informal sectors are denoted $h^F_t$ and $h^I_t$, respectively. The discount factor $\beta$ takes values between 0 and 1. Parameter $\kappa > 1$ determines the wage elasticity of labor supply. Parameter $\sigma > 0$ determines the intertemporal elasticity of substitution $1/\sigma$. Parameter $a$ determines the weight of each consumption good in the CES aggregator, while $e$ determines the elasticity of substitution between formal and informal consumption. $1/(1 - e)$.

The sequential budget constraint is

$$q_tD_{t+1} = C^F_t + p_tC^I_t + I^F_t + p_tI^I_t + D_t - (W_t h^F_t + r_t K^F_t) (1 - \tau^Y) - p_t Y^I_t. \tag{2}$$

The numeraire is the formal good. The relative price of the informal good is $p_t$. $D_{t+1}$ is the stock of debt the household can issue at a price $q_t$ in world markets in $t$ to be redeemed in $t + 1$. $I^F_t$ is investment in the formal sector. $I^I_t$ is investment in the informal sector. $W_t$ is the salary per unit of labor in the formal sector. $r_t$ is the rental rate of capital to the formal firm $K^F_t$. $Y^I_t$ is the amount of income generated in the informal/self-employment sector. $\tau^Y$ is the income tax rate applied to flows of income from the formal sector. Upper (lower) case variables (do not) trend in the balanced growth path.

The representative household faces a technology in the self-employed sector given by

$$Y^I_t = a^I_t \left( K^I_t \right)^{\alpha^I} \left( \Gamma^I_t h^I_t \right)^{1 - \alpha^I} \tag{3}$$

where $a^I_t$ is the transient productivity in the informal/self-employed sector, $K^I_t$ is the stock of capital used by the informal sector and $\Gamma^I_t$ is an informal labor augmenting productivity process. The capital income share is $\alpha^I$. 

19
We allow for two independent capital laws of motion

\[ K_{t+1}^F = I_t^F + K_t^F (1 - \delta) \]  

\[ K_{t+1}^I = I_t^I + K_t^I (1 - \delta) \]

where \(0 < \delta < 1\) is the depreciation rate.

The problem of the consumer is to maximize (1) subject to (2), (3), (4), (5), together with a no-Ponzi condition.

### 4.2 The representative formal firm

The representative firm that operates in the formal sector maximizes profits, \(\Pi_t\) each period \(t\), defined as

\[ \Pi_t = Y_t^F - (1 + \tau^N) W_t h_t^F - r_t K_t^F \]

where \(\tau^N\) is the tax on the wage bill.

The technology faced by the formal sector is given by

\[ Y_t^F = a_t^F \left( K_t^F \right)^\alpha \left( \Gamma_t^F h_t^F \right)^{1-\alpha} \]

where \(a_t^F\) is the transient productivity in the formal sector and \(\Gamma_t^F\) is the formal labor augmenting productivity process. We allow for a different capital income share \(\alpha\) than in the informal sector.

The static problem of the firm is to maximize (6) subject to (7).

### 4.3 Government

The government runs a balanced budget in every period:

\[ \tau^N W_t h_t^F + (W_t h_t^F + r_t K_t^F) \tau^Y = G_t \]  

(8)
where government spending $G_t$ equals total tax revenue.

### 4.4 Interest rates

The interest rate on the debt issued in world capital markets is equal to the inverse of the price of the debt which we assume to be equal to a constant interest rate and an interest premium. We assume that

$$
1/q_t = R + \tilde{\psi}\left(\tilde{D}_{t+1}/\Gamma_t^F\right)
$$

(9)

where $\tilde{\psi}\left(\tilde{D}_{t+1}/\Gamma_t^F\right)$ is an aggregate-debt elastic premium stemming from deviations from a long run level of debt, and $R$ is the long run interest rate that the small open economy faces in world capital markets. Following Schmitt-Grohe and Uribe (2003) we define $\tilde{\psi} (\cdot)$ as follows

$$
\tilde{\psi}\left(\tilde{D}_{t+1}/\Gamma_t^F\right) = \psi \left[\exp \left(\tilde{D}_{t+1}/\Gamma_t^F - d\right) - 1\right]
$$

with $\psi > 0$, and $d$ being the long run (normalized) steady state of debt. This premium will have no effect in the short run fluctuations of the model because we will calibrate $\psi$ to be small following the literature. Last, note that in equilibrium aggregate debt $\tilde{D}_{t+1}$ and consumer’s debt $D_{t+1}$ coincide.

### 4.5 Balance of payments

Net exports equal the change in debt plus interest payments

$$
nx_t = D_t - q_t D_{t+1}.
$$

### 4.6 Formal and informal goods market clearing

$$
Y_t^F = C_t^F + I_t^F + G_t + D_t - q_t D_{t+1}
$$

$$
Y_t^I = C_t^I + I_t^I
$$
Hence we define the trade balance share as

\[ n_x y_t = \frac{Y_t^F - C_t^F - I_t - G_t}{Y_t^F}. \]

### 4.7 Productivity processes

We assume that log levels of the formal transitory technology process evolve as an AR(1) process

\[ \ln a_{t+1}^F = \rho_a \ln a_t^F + \varepsilon_{t+1} \]

with \(0 < \rho_F < 1\) and variance of the shock \(\sigma_a^2 > 0\).

The process for the informal transitory technology process is a function of its previous value and of the current transitory value of the process in the formal sector:

\[ a_t^I = (a_{t-1}^I)^{1-\omega} (\gamma a_t^F)^\omega \]

where \(\omega\) and \(\gamma\) are between 0 and 1. These parameters define the extent to which shocks in the transitory technology of the formal sector pass-through to the informal sector.

With respect to the labor augmenting trends, we assume that

\[ \frac{\Gamma_t^F}{\Gamma_{t-1}^F} = g_t^F. \]

We call \(g_t^F\) a growth shock. We assume that

\[ \ln \left( \frac{g_{t+1}^F}{\mu} \right) = \rho_g \ln \left( \frac{g_t^F}{\mu} \right) + \varepsilon_{t+1}^g \]

where \(0 < \rho_F < 1\) and variance of the shock \(\sigma_g^2 > 0\). Parameter \(\mu\) is the long run growth rate of labor augmenting productivity.

We assume these relate to the informal sector as follows

\[ \frac{\Gamma_t^I}{\Gamma_{t-1}^I} = g_t^I \]
\[ g_t^F = (g_{t-1}^F)^{1-\omega} (g_t^F)^{\omega}. \]

Hence, we can express the levels of labor augmenting productivity in both sectors as a product of the growth shocks:

\[
\Gamma_t^I = \Gamma_0^I \prod_{j=1}^{t} g_j^I \\
\Gamma_t^F = \Gamma_0^F \prod_{j=1}^{t} g_j^F.
\]

We assume that the initial difference between \( \Gamma_0^I \) and \( \Gamma_0^F \) is pinned down by \( \gamma \) given that \( \Gamma_0^I = \gamma \Gamma_0^F \). As shown in the appendix (ME PARECIÓ MEJOR PASAR ESTO AL APPENDIX), under plausible calibration \( \Gamma_t^I < \Gamma_t^F \) for all \( t \).

Last, but crucially for our purpose, in the long run

\[
\frac{\Gamma_t^F}{\Gamma_t^F - 1} = \frac{\Gamma_t^I}{\Gamma_t^I - 1} = \mu
\]

which allows us to compute a balanced growth path equilibrium.

### 4.8 Competitive equilibrium

Given initial conditions \( K_0^F, K_0^I, \) and \( D_0 \), and exogenous state-contingent sequences of transitory technology shocks \( a_t^F \) and growth shocks \( g_t^F \) in the formal sector, an equilibrium is a state-contingent sequence of allocations \( \{C_t^F, C_t^I, h_t^F, h_t^I, d_{t+1}, I_t^F, I_t^I\} \) and of prices \( \{W_t, r_t\} \) such that:

1. The allocations solve the consumer’s problem given prices, the laws of motion for the capital stocks, the laws of motion of shocks in the informal sector, and government spending.
2. The allocations solve the formal firm’s problem given prices.
3. The government satisfies its budget constraint each period.
4. Markets clear for capital, labor and goods in the formal and informal sectors.
4.9 Solution of the model

The first order conditions of the consumer and of the firm’s problem appear in the Appendix, together with the rest of the equations that define the competitive equilibrium. We use Uribe and Schmitt-Grohe’s perturbation method via modified versions of their codes to solve for the equilibrium. To do so, given that our model includes growth trends, we detrend the system of equations to find the stationary solution. The Appendix presents the list of nonstationary and stationary equations.

5 Calibration

We calibrate a subset of parameters using the stationary system of equations evaluated at the non stochastic steady state (NSSS). A summary of the calibrated values is reported in Table V.1. Parameter $e$ determines the elasticity of substitution between formal and informal goods. We follow Restrepo-Echavarria (2011), who chooses a value of $e = 0.875$, implying an elasticity of 8. Restrepo-Echavarria (2011) argues that formal and informal goods are very good substitutes. To provide and illustration, she describes that there are well-known informal markets in some of the largest metropolitan areas of Latin America where consumers can buy, for example, the same electronics as in a formal shopping mall. Some differences remain, though. For example, only formal vendors provide a factory warranty. Another argument for using a high elasticity of substitution is a comparison to the household production literature. Restrepo-Echavarria (2011) reports that previous research in that literature has used an elasticity of 5 between market and non-market activities. She argues, for example, that there is a higher substitution between a meal in the formal and informal sectors versus a dinner in a restaurant and dinner cooked at home. Therefore the elasticity should be higher than 5, and she chooses 8.

We calibrate $\tau^h$ and $\tau^Y$ following the methodology in Mendoza, Tesar and Razin (1994). The tax rate $\tau^Y$ that we measure corresponds to the tax rate on total income $\tau_h$ in Mendoza et al.’s paper. They measure this tax as the ratio of aggregate individual income tax revenue to pre-tax household income. Pre-tax household income is defined as the
sum of wages and salaries, property and entrepreneurial income, and the operating surplus of private unincorporated enterprises. We obtain data for these variables. We then calibrate $\tau_Y$ as the ratio of aggregate individual income tax revenue to the sum of wages and salaries, and household income from capital.\textsuperscript{24} We exclude the operating surplus of private unincorporated enterprises from the tax base because a part of this income comes from informality, and is not taxed.\textsuperscript{25} The average value of $\tau_Y$ using annual data from 2003 to 2008 is 0.07223. To calibrate $\tau_N$ we follow a similar strategy. Mendoza et al. (1994) did not measure this tax, but we follow similar steps. We collect data on tax collection and tax base, in this case regarding the payments that firms make as social contributions, and which represent an increasing function of the wage bill.\textsuperscript{26} Using data from 2003 to 2008 we find an average value of $\tau_N = 0.1142$.

Regarding capital income shares, we set the one in the formal sector equal to $\alpha = 0.35$, following Garcia-Verdu (2005) who finds that the share in Mexico has a value similar to the one in the U.S. We set the capital share in the informal sector following Restrepo-Echavarria (2011) who uses $\alpha_I = 0.2$, citing evidence that formal production is more capital intensive.

Other parameters have a standard calibration. We set parameter $\sigma$, which determines the intertemporal elasticity of substitution $1/\sigma$, equal to 2 implying an elasticity of 0.5. Parameter $\kappa$ determines the wage elasticity of labor supply. Values around 1.5 are common in the literature. We set $\kappa = 1.6$ following the RBC of model Aguiar and Gopinath (2004) estimated on the Mexican economy. Regarding the depreciation rate $\delta$, we set it equal to the value used in Aguiar and Gopinath (2007), which is 5 percent. We calibrate $\mu$ to the average (quarterly) growth factor of the Mexican economy and is set to $\mu = 1.006$. The constant gross interest rate $R$ paid by the economy with data on country interest rates on Mexico from Uribe and Yue (2005). Specifically, we set the quarterly value of $R$ equal to 1.0145. With these last two parameters and the stationary Euler equation for bonds evaluated at the steady state, $1 = R\beta\mu^{-\sigma}$, we get a value for the discount factor $\beta$ equal to 0.9976. We set the

\textsuperscript{24}Data on income tax come from the OECD, as in Mendoza et al.’s paper. The data on factor payments comes from the INEGI website. Payments to labor are "sueldos y salarios, economía total", in Spanish. Payments to capital are "excedente bruto de operacion, hogares", in Spanish.
\textsuperscript{25}INEGI (YEAR?) reports a measure of the size of the informal sector in Mexico. Most of informal GDP comes from the operating surplus of private unincorporated enterprises, or mixed income ("ingreso mixto", in Spanish).
\textsuperscript{26}The source is the INEGI website, in particular the section on national accounts.
interest rate premium parameter $\psi$ to a small value as in Schmit-Grohé and Uribe (2003), $\psi = 0.00001$.

When calibrating $\gamma$ we start from the production function of each of the two sectors. After some algebra, one can show that, in the steady state the ratio of formal to informal productivity levels is

$$\frac{TFP^F}{TFP^I} = \frac{\mu^{-\alpha_I+\alpha_I}}{\gamma_I}$$

Next we use Busso et.al. (2012) results to pin down the ratio of productivities in the Mexican data. To do so, we assume that TFP levels in the formal sector is the weighted sum of the productivities in the legal/formal and legal/semi-formal firms (see the discussion in the Stylized Facts sections), while that in the informal sector is simply that of the legal and informal ones. We do so in order to abstract from the firms that hire workers but illegally as such firms are not properly captured in our theoretical framework. Formally, we assume:

$$TFP^F = \alpha_{LF} \cdot TFP^{LF} + \alpha_{LS} \cdot TFP^{LS}$$

$$TFP^I = TFP^{LI}$$

where $\alpha_{LF}$ and $\alpha_{LS}$ denote the shares of each of the two types of firms weighted by number of workers. Using the information in the appendix in Busso et.al. (2012), these two are $\alpha_{LF} \simeq 0.8697$ and $\alpha_{LS} \simeq 0.1303$. Then the ratio of productivities can be expressed as follows:

$$\frac{TFP^F}{TFP^I} = \frac{\alpha_{LF} + \alpha_{LS} \cdot \frac{TFP^{LS}}{TFP^{LI}}}{\frac{TFP^{LI}}{TFP^{LI}}}$$

To find the ratios $\frac{TFP^{LS}}{TFP^{LI}}$ and $\frac{TFP^{LI}}{TFP^{LI}}$ we use Busso et.al. (2012)’s estimates of the expected difference in the (log) ratios of productivities in between $LF$ and, respectively, $LS$ and $LI$, in Mexico. According to their estimates (see Table 9 in Busso et.al, 2012):

$$\log \left( \frac{TFP^{LS}}{TFP} \right) - \log \left( \frac{TFP^{LF}}{TFP} \right) = -0.627$$

$$\log \left( \frac{TFP^{LI}}{TFP} \right) - \log \left( \frac{TFP^{LF}}{TFP} \right) = -2.426$$
From this information, we recover can recover a productivity ratio, $\frac{TFP^F}{TFP^I}$, of 2.1901. This in turn, coupled with our previous steady state result that mapped this ratio in the model to $\mu^{-\alpha_1+\beta_1}/\gamma^{\alpha_1}$, gives us a value for $\gamma$ equal to 0.0198.

We now discuss the calibration of $a$. This parameter determines the importance of the consumption of formal goods $C^F$ in the consumption aggregator $C$. In the Appendix we present a system of equations evaluated at the NSSS that we use to pin down the value of $a$. This system uses information on the ratio of self-employment to total employment. We use the value 0.3514, which is the average between the levels of informality across definitions 1, 2 and 4 mentioned in the empirical section\(^{27}\). In some of the robustness checks we consider other values for this share too.

In the case of $d$, the debt level in the interest rate premium, as is typical in SOE-RBC models this value is not pinned down internally. The number chosen as the debt-to-GDP ratio is the same used by Aguiar and Gopinath (2007).

The remaining five parameters $\omega, \rho_a, \sigma_a, \rho_g, \sigma_g$ govern the dynamics of the model around the steady state but do not affect it. We choose to calibrate the persistence of both shocks to the values estimated by Aguiar and Gopinath (2004), $\rho_a = 0.94$, $\rho_g = 0.72$. The other three parameters we calibrate to match a specific subset of moments from the data. Formally we calibrate $\omega$, $\sigma_a$ and $\sigma_g$ by solving

$$
\min_{\{\omega, \sigma_a, \sigma_g\}} \left[ \frac{M_j(\omega, \sigma_a, \sigma_g) - M_j^d}{M_j^d} \right]' \Gamma_j \left[ \frac{M_j(\omega, \sigma_a, \sigma_g) - M_j^d}{M_j^d} \right]
$$

where $M_j^d$ denotes the $j^{th}$ subset of moments in the data, $M_j(\omega, \sigma^a, \sigma^g)$ is its model counterpart, and $\Gamma_j$ is a weighting matrix associated with $j$. In the empirical implementation we assess several subsets of moments along with various candidates for $\Gamma_j$. We solved this minimization problem by postulating a grid for each of the three parameters and computing the minimum element among all possible elements of the grid, while checking that such minimum was not satisfied at the boundaries of the grids. Our choice of what parameters to calibrate in this minimization procedure was guided by both computational limitations (i.e. the curse

\(^{27}\)We exclude definition 3 given that this measure was the only one different from the other four measures in the dynamics explored in the section on Stylized Facts.
of dimensionality) and the goal of our research. Because ultimately we are interested in
assessing the robustness of the relative strength of growth shocks vis-à-vis stationary shocks
found in AG, we considered that it was a natural starting point to use their point estimates
for the persistence of both shocks while allowing for the model to inform us about their
standard deviation. Lastly, given that \( \omega \) is not a standard parameter in the literature we
opted to include it also in the minimization criteria to assess how much information about
it one could retrieve when taking the model to the data.

6 Results

This section discusses the main quantitative results obtained from the model. These are
divided into three blocks. First, we document how \( \omega \), a key parameter that determines the
pass-through of shocks from the formal to the informal sector, affects the dynamics of the
model. Second, we study the performance of the model in terms of accounting for some of the
key second moments that characterize Mexican business cycles, across various calibrations
of some of the parameters in the model. Finally, we report and assess the model’s impulse
response functions.

Figure VI.1 presents the model’s implied second moments across all the values in the
grid of \( \omega \). The upper panel A displays, in the left axis, the standard deviation of formal
output, and, in the right axis, the relative standard deviation of formal, informal and total
labor, as well as that of consumption. The lower panel B reports the serial correlations of the
same variables with formal output. All moments are computed on the HP-…ltered variables.

The main message that emanates from these two plots is that lower values of \( \omega \) translate
into stronger volatility in labor markets. This, in turn, impacts the volatility of formal
output. Intuitively, lower values of the pass-through imply that shocks in the formal sector
are imperfectly transmitted into the informal sector. This will then generate the incentives

\footnote{The grid for \( \omega \) is comprised of twenty equally spaced points in the interval \((0, 1)\). Four points had to be
slightly adjusted to avoid indeterminacy of the solution. The other parameters are calibrated according to
Table V.1 and Case I in Table VI.1.}

\footnote{We did not resort to simulations to compute HP-…ltered second moments implied by the model. Instead
we computed analytical ones by including the HP-cyclical component of each variable into the model when
solving it. See the Appendix for details.}
for workers to move from one sector to the other with real effects in the production of both sectors. For example, a positive productivity shock will not percolate into the informal sector as strongly, thereby providing the incentives for people to move out of the informal sector. As Panel B shows, the lower \( \omega \) is, the stronger this reallocation of resources will be, and the more countercyclical informal labor will become. Hence the increase in formal production will be bigger. This constitutes one of the key findings derived from the model: the presence of an informal sector coupled with imperfect pass-through of shocks across sectors constitutes a powerful amplifying mechanism for shocks in emerging economies.

There are other two interesting findings that can be seen from Figure VI.1. One is that, as \( \omega \) is reduced and labor in both sectors becomes more volatile, aggregate labor becomes actually less volatile. This is due to the fact that labor in the formal (informal) sector becomes more procyclical (countercyclical). These two dynamics offset each other in the aggregate. The other finding is that the increase in the volatility of formal output generated by lower values of \( \omega \) more than compensates that of formal consumption. This makes consumption relatively less volatile to output in the formal sector for low values of this parameter.

The second set of quantitative results from the model is reported in Table VI.1 where we compare the empirical second moments (column 1) with the theoretical ones derived from the model across various calibrations for \( \omega, \sigma_a, \sigma_g \) (columns 2 to 10). In particular, we consider eight different case: Case I (II) where \( \sigma_a \) and \( \sigma_g \) are set to the same values estimated by Aguiar and Gopinath (2004) and \( \omega \) is set to 0.05 (0.95), the minimum (maximum) value in the grid of this parameter; Case III where, again, \( \sigma_a \) and \( \sigma_g \) are set as in AG and \( \omega \) is pinned down by solving INCLUIR ACA NUM DE LA EQ. and setting \( M_{d}^{j} = \rho (Y^{F}, h^{I}) \) and \( \Gamma_{j} = I_{1} \) (where \( I_{1} \) is the identity matrix of dimension one); Case IV where \( \sigma_a, \sigma_g \) and \( \omega \) are pinned down by solving NUM EQ., while setting \( M_{d}^{j} = [\rho (Y^{F}, h^{I}), \sigma (Y^{F}), \sigma (C^{F})] \) and \( \Gamma_{j} = I_{3} \); Case V is identical to Case IV except that \( \Gamma_{j} \) is set equal to the inverse of a diagonal matrix whose elements are the standard deviations of the three empirical moments; Case VI where, again, all three parameters are set to solve EQ. ACA but this time \( M_{d}^{j} \) is a 22x1 vector containing the 14 moments in Table VI.1 plus the 8 serial correlations between formal output and informal labor \( \rho (Y_{t}^{F}, h_{t+j}^{I}) \), with \( j = -4, \ldots, 4 \), and \( \Gamma_{j} = I_{22} \); Case VII
is identical to Case VI except that $\Gamma_j$ is set equal to the inverse of a diagonal matrix whose elements are the standard deviation of all 22 moments considered; and Case VIII is identical to case VI except that the model is solved assuming an informal labor share equal to FALTA.

Several results emanate from Table VI.1. Cases I and II show that the using the estimated variance of the two shocks from AG grossly overestimates the volatility of all the macro variables considered. For instance, output’s standard deviation is 8.8, close to four times the one observed in the data. This gap between the model and the data increases in Case II where the standard deviation of output increases to 19.3. Moreover in both Cases I and II the model predicts a cyclicality of informal labor largely at odds with the observed one. This is immediate after inspecting Figure VI.2 where the model’s implied serial correlation between income and informal labor is plotted for each of the eight cases, and compared to the empirical counterpart (CI stands for confidence internal). For the latter we use using Mexico’s $L^4_I$ measure for 1987-2003. In Case I, where $\omega$ is calibrated to 0.95, the model counterfactually generates procyclical informal labor. In Case II, on the contrary, the model does generate counterfactual informal labor, but it grossly overstates it.

Another salient failure of the model in Case I is the fact that it predicts informal labor to be equally volatile as that in the formal sector. In the Mexican data, however, the latter is almost twice volatile. This failure is nonetheless largely closed in Case II but with the poor match in the other dimensions that we have highlighted.

The results from Case III show that the model can indeed reproduce negative correlations between output and informal labor similar to those observed in the data, provided that there is an imperfect pass-through of shocks from the formal to the informal sector. In particular the calibration results show that for values of $\omega$ in the order of 0.65 such close match can be obtained. Figure VI.2 shows that, under this calibrated value for $\omega$, the model is able to account for the empirical pattern of the serial correlation between income and informal labor. Still, however, the model is generating much more volatility in all macro variables if we continue to assume AG’s estimates for $\sigma_a$ and $\sigma_g$, as we do in Case III. In addition, the model counterfactually predicts that labor informality is half as volatile relative to formal labor.

The fit of the model improves considerably in Case IV where $\sigma_a$ and $\sigma_g$ are also cal-
ibrated according to PLACE EQ HERE. As expected, the values for these two parameters drop compared to those estimated by AG. In particular, they roughly fall by an order of magnitude: according to the results of the calibration \( \sigma_a = 0.04 \) and \( \sigma_g = 0.31 \), in percentage terms, compared to 0.41 and 1.09, respectively, from AG. Interestingly, while the size of variance of both shocks falls, growth shocks remain to be relatively more important than transient ones. The ratio \( \sigma_a/\sigma_g \) drops to 0.14, which is less that half the ratio estimated by AG (0.38). An overall assessment can be based on the random walk component (RWC) of the Solow residual\(^{30}\) which increases to 6 from AG’s estimated value of 5.27. The model is now able to closely match the volatility of output. It also reproduces a consumption path that is as procyclical and relatively more volatile as in the data. And it continues to generate the countercyclical dynamics of labor informality when \( \omega \) is calibrated to 0.65 (see Figure VI.2). However, the model continues to generate a lower volatility of informal labor. It also generates a path of investment that is both excessively volatile and much less procyclical compared to that in the data. This, in turn, implies that the model-generated trade balance is both much more volatile and less countercyclical than its empirical counterpart. Some of the extensions explored in the next section will deal with how much the latter is resolved once one assumes ad-hoc capital adjustment costs as is traditionally assumed in the literature.

The reasonably good fit of the model with the calibration in Case IV continues to hold in the other cases where we take into account more second moments (e.g. Case VI) and the precision with which the moments are measured (e.g. Cases V and VII). The calibration continues to point to more moderate shocks and an even more predominant role of growth shocks. Likewise, the model continues to generate volatilities that are aligned with the data in almost all variables (with the exception of investment and informal labor) while simultaneously accounting for the countercyclicality of informal labor. This is also the case when the steady state share of informal labor is assumed to double relative to the other cases, as as we do in Case VIII.

Further assessment of the dynamics implied by the model can be made by studying the impulse response functions (IRF). These are reported in Figure VI.3 and display the

\[^{30}\text{We follow Aguiar and Gopinath (2007) in defining the RWC as }\]

\[
\frac{a^2\sigma_g^2}{(1 - \rho_g)^2} / \left\{ \frac{2}{(1 + \rho_a)} \sigma_a^2 + \left[ a^2\sigma_g^2 / (1 - \rho_g^2) \right] \right\} .
\]
dynamics following a one standard deviation shock in each of the two stochastic processes. For that purpose, we use the calibration in Case VII in Table VI.1 when computing the IRF. The main message from Figure VI.3 is that growth shocks are, by and large, the main drivers of aggregate fluctuations in both formal and informal sectors. And studying the labor market in both formal and informal sectors is informative in terms of the propagation mechanism of these shocks. Following a growth shock employment increases in both sectors. But the subsequent dynamics are strongly asymmetric across sectors. While in the informal sector employment quickly decreases below its steady state, in the formal sector the opposite occurs, and employment rises for a few quarters. This comes from the fact that growth shocks are imperfectly transmitted from one sector to the other, hence agents find it optimal to relocate away from the informal and into the formal sector. The relatively higher productivity in the formal sector is also responsible for the disproportionately larger jump in investment in the formal sector relative to the informal one. These two forces combined, plus the asymmetric initial shock to TFP make output in the formal sector increase more than in the informal sector. This, in turn, explains why the relative price of informal goods rises above its steady state. The IRF following a transitory productivity shock are qualitatively similar but are dwarfed in magnitude by those computed after a growth shock. Evidently, the lion’s share of the business cycle dynamics is associated to the latter type of perturbation\textsuperscript{31}.

Summing up, the results support the view that including labor informality into an otherwise standard SOE-RBC model acts as a powerful amplifier of shocks. Importantly, they also show that the degree of imperfect pass-through of TFP shocks from the formal to the informal sector is a key element for the model to properly account for the countercyclicality of informal labor observed in the data.

\textsuperscript{31}Qualitatively, there is one notable difference across the IRF. Those coming from a growth shock do generate responses in consumption that are stronger in magnitude to those from transitory shocks. This is in line with AG and explains the need for the model to keep resorting to growth shocks. In the section Extensions we will provide further details about this.
7 Extensions

In this section we study the sensitivity of our results to changes in the economic environment. In the first modification we introduce adjustment costs on the capital stocks of both formal and informal sectors. In the second, we assume that a fraction of informal output is counted in the model’s measure of "official GDP" and other macroeconomic variables. Here we are taking into account that Mexico’s statistical agency measures a fraction of informal output and includes it into the official measure of GDP. Finally, we allow for the pass-through of shocks from the formal to the informal sector to differ across the two types of shocks that we consider.

7.1 Capital adjustment costs

In our first set of comparisons of model versus data moments we found that investment was relatively less procyclical and more volatile than in the data. In this modification we introduce a cost for adjusting the stock of capital in each of the two sectors. We follow the literature on business cycles in emerging economies (e.g. Aguiar and Gopinath 2007; Garcia-Cicco et al. 2010) where researchers assume the presence of a convex cost function in which increases in the growth of capital beyond its balanced-growth path growth reduce the accumulation of capital. The cost function has a parameter, \( \phi \), that we will calibrate to bring the model closer to the data. Formally, we assume that the laws of motion for the capital stock in the formal and informal sectors are, respectively:

\[
K_{t+1}^F = I_t^F + K_t^F (1 - \delta) - \frac{\phi}{2} \left( \frac{K_{t+1}^F}{K_t^F} - \mu \right)^2 K_t^F
\]

\[
K_{t+1}^I = I_t^I + K_t^I (1 - \delta) - \frac{\phi}{2} \left( \frac{K_{t+1}^I}{K_t^I} - \mu \right)^2 K_t^I.
\]

We assume the depreciation rate is the same across sectors. We also assume that the adjustment cost parameter \( \phi > 0 \) is the same across sectors. We make this choice because even though we know that the informal sector uses capital to produce, there are no data on investment by this sector that would allow us to calibrate a parameter for each capital. When assessing the robustness of our benchmark results to this extension, we included \( \phi \) in the set
of parameters considered when solving the minimization problem we use for calibration.

Table VII.1 presents the results of Extension I in terms of the new values for the calibrated parameters as well as the model performance in terms of second moments. In this case $M^d$ includes all 22 moments and $\Gamma$ is the identity as in Case VI. The calibrated value for $\phi$ is 0.21. While this value is lower relative to the calibrated values used in the earlier studies mentioned above, it is enough to curb down investment volatility and increase its procyclicality. This in turn contributes to close the gap between the model and data in terms of the trade balance behavior. Simultaneously, the main results from Case VI remain. Notably the model continues to exhibit strong propagation of shocks that results in the size of their variance to be much smaller than in previous studies, and growth shocks continue to be more important in generating business cycles. Moreover, Figure VII.1 shows that the model continues to replicate properly the countercyclicality of informal labor. This is a consequence of an even larger imperfect pass through of shocks from the formal to the informal sector as the calibrated value drops to 0.5, relative to the value of 0.65 in the benchmark case.

The IRF for this case are plotted in Figure VII.2. Qualitatively, the dynamics are similar to the benchmark case. Most of the fluctuations generated by the model are linked to growth shocks and the salient differences in the dynamics of the two types of labor continue. As expected, however, the path of investment is now much more smooth relative to the case in the absence of capital adjustment costs. This, in turn, generates smoother IRF in trade balance and output.

The model with capital adjustment costs reproduces closely, as we have discussed, several dimensions of the data. At this point we would like to study the following: why do growth shocks continue to be more important when taking the model to the data? To answer this we considered two separate experiments. First, we set all parameters equal to their calibrated value in Extension I, except that we counterfactually set $\sigma^g = 0$. Second, we solved the minimization problem again, keeping the assumption of $\sigma^g = 0$. The results of the two experiments are reported in columns three and four of Table VII.1, labeled as Extension II and III, respectively. As expected, the volatility of most macro aggregates drops substantially. Consumption is the most salient one as its standard deviation falls below the one of output. The model now also fails to capture the countercyclicality of informal
labor, as can be also seen by inspecting Figure VII.1. This failure is remedied to a large extent in Extension III where we recalibrate the volatility of transitory shocks. Importantly, however, the model continues to fail to account for the volatility of consumption. Thus, in our calibration, growth shocks continue to be relevant mostly to be able to replicate this salient feature of the Mexican data.

7.2 Imperfect measurement of the informal sector

An important question regarding national accounts in emerging countries is to what degree they include the informal sector. In the case of Mexico, the national statistical agency reports a measure of informal GDP that is included in the GDP reported overall. See INEGI (2006). We take that into account in this section.

More generally, what we are doing here is to relax the assumption that no dynamics of the informal economy are included in the measurement of the macro statistics that we use to calibrate the parameters of the model. However, following the discussion in the Empirical Evidence section in terms of the potentially large under-measurement issues of the informal economy, we assume that only a fraction \( \theta \) of the informal economy is registered. This number will be calibrated in such a way that in the NSSS the registered informal economy as a share of the total economy is equal to what the Mexican statistical agency reports. We create four new measurement equations that define output, consumption, investment, and the trade balance including the fraction \( \theta \) of informal activity. The four new equations are:

\[
\begin{align*}
Y_t^{d} &= Y_t^{F} + \theta p_t Y_t^{I} \\
C_t^{d} &= C_t^{F} + \theta p_t C_t^{I} \\
I_t^{d} &= I_t^{F} + \theta p_t I_t^{I} \\
x_t^{d} &= Y_t^{d} - C_t^{d} - I_t^{d} - G_t
\end{align*}
\]

where \( d \) stands for "data", referring to what is actually reported in Mexican statistics. For example, \( Y_t^{d} \) stands for GDP reported by the Mexican statistical agency. Part of it is formal, and part of it is the fraction of informal output that the statistical agency is able to measure.
We are assuming that the fraction of informal activity measured in consumption is identical to that of investment goods. We assume that government spending remains a function of the taxes on the formal sector, as in the benchmark model:

$$\tau N W_t h_t^F + (W_t h_t^F + r_t K_t^F) \tau Y = G_t.$$

The NSSS is the same as the one found in the benchmark case. We use it to calibrate $\theta$ as follows. Once $Y^F$, $p$, and $Y^I$ are pinned down, we choose $\theta$ so that:

$$\frac{\theta p Y^I}{Y^F + \theta p Y^I} = \Omega$$

where $\Omega$ is the share the total economy that is both informal and registered by the Mexican statistical agency. We set $\Omega = 0.124$ to be consistent with the section on Empirical Evidence where we reported that number. This yields a calibrated value of $\theta$ equal to .

We replicate the experiment in Extension I using the new four variables in the model when computing the model-based moments and comparing those to Mexican data. The results of this experiment are reported in the Column labelled Extension IV in Table VII.1. Overall the results are strongly robust. The volatilities of shocks continue to be relatively low compared to the AG estimates and growth shocks are relatively stronger. The performance of the model in accounting for the second moments continues to be satisfactory. While the contemporaneous correlation between informal labor and income slightly increases, overall the countercyclicality of informal labor continues to be in line with the data as can be seen from Figure VII.1, where we display the contemporary and dynamic correlations.

### 7.3 Assymetric pass through

In this section we allow for a more general transmission of shocks from the formal to the informal sector. We assume that there is a specific parameter $\omega$ for transitory and for growth shocks. We want to capture the possibility that level and trend shocks in the formal sector have a differential impact on the level and trend shocks in the informal sector. In the specification we study, the impact of a formal-sector growth shock on the informal sector
may be of different magnitude than the impact of a transitory shock. Specifically, now the process for the informal transitory technology shock is affected by parameter $\omega_a$:

$$a^I_t = \left( a^I_{t-1} \right)^{1-\omega_a} \left( \gamma a^F_t \right)^{\omega_a}.$$ 

With respect to the labor augmenting growth shock we assume it is determined in part by $\omega_g$:

$$g^I_t = \left( g^I_{t-1} \right)^{1-\omega_g} \left( g^F_t \right)^{\omega_g}.$$ 

As before, we assume $\omega_a$ and $\omega_g$ are between 0 and 1. We calibrate both parameters by including them in the set of parameters considered when solving the minimization procedure we use to calibrate. As in Extension 1, $M^d$ includes all 22 moments and $\Gamma$ is the identity.

The results of this experiment are reported in the last column of Table VII.1, under Extension V. The most interesting outcome of these results is that the calibrated value for $\omega_a$ is now 0.1, considerably lower relative to the value for $\omega_g$, 0.6. This further reiterates the previous results in the sense that, through the lens of our model, TFP shocks are imperfectly transmitted from one sector to the other. Simultaneously, the findings from the benchmark model continue to hold. The model continues to closely match some of the key second moments in the data, particularly the dynamics of informal labor (see also Figure VII.1). The random walk component remains high and of similar magnitude to the one AG estimated.

8 Concluding remarks

Despite the fact that labor informality is a widespread phenomenon in emerging market economies, it has received very little attention from macroeconomists interested in business cycles in these economies. We have argued that this is an important omission in the literature and have presented empirical and theoretical evidence to back our case. On the empirical side we built relatively long quarterly time series for various proxies of labor informality in Mexico, an emerging economy, and documented how they are all strongly countercyclical. This, in turn, explains why total employment is less procyclical and volatile relative to Canada, a developed counterpart economy. We also provide evidence of these links between
labor informality and aggregate employment across a wider pool of emerging and developed small open economies.

From a theoretical perspective, we also back our case by documenting the non trivial effects of introducing an informal labor market into an otherwise standard business cycle model of a small open an emerging economy. We introduce this by assuming that workers optimally choose between a (taxable) formal wage or an informal (tax-free) compensation from self-employment, and calibrate the productivity and tax levels in both activities from Mexican firm-level and fiscal data. We also assume that shocks are imperfectly transmitted from the formal to the informal sector. We show how these new ingredients act as powerful propagation mechanisms for shocks that have been identified in earlier studies as key drivers of business cycles in emerging economies. We focus specifically in the role of shocks to the trend of the labor-augmenting productivity process, which have been found in earlier studies to be responsible for most of the aggregate fluctuations in emerging economies. Through the lens of our model, while these shocks continue to be relevant, their required size (measured by their standard deviation) in order to reproduce realistic business cycles reduces to 1/4 of the size found in these studies. The model can also capture key stylized facts in the labor market such as the moderate procyclicality and volatility of total employment and, importantly, the large countercyclicality of informal labor. It can also account for other business cycle dynamics typical to emerging economies such as the large volatility of consumption and investment, as well as the countercyclicality of the trade balance.

We have only scratched the surface of the role of the informal sector in emerging market business cycle and our work can be extended in many ways. The theoretical framework with which we model labor informality in a dynamic general equilibrium setup is deliberately simple in order to keep the intuition straightforward. But the cost of doing so is that we abstract from interesting issues. For instance, it would be worth exploring more linkages between formal and informal sectors as the two have remained mostly isolated in our framework, while the data reveals that there may be important interlinkages. Another interesting area is to explore more the largely imperfect transmission of shocks across sectors that we identify when taking our model to the data. This imperfect transmission of shocks is, by and large, a reduced-form device to capture institutional barriers that prevent shocks to
fully spread across labor markets. It would certainly be of interest to dig deeper into the sources of these barriers. Finally, it would be worth expanding our analysis to a larger pool of countries although the availability of data on informal activities would be an important challenge to overcome.

References


FIGURES AND TABLES

Figure III.1. Income and Self-employment: Emerging and Developed Economies

Note: Self Employment denotes the self-employment rate and the axis is in percentage. Each point represents the average for each country calculated over all the years in which we had available data from 1999 to the present. Source: WEO, LABORSTA (ILO).

Figure III.2. Income and Informality in Emerging Economies

Note: Informality refers to the percentage of total employment who works in the informal sector as measured by KILM. Each point represents GDP per capita and informality for a given country in a given year. Source: WEO, KILM (ILO).
Figure III.3. Self-employment and Procyclicality of Total Employment

Note: The vertical axis shows the correlation between the cyclical components of total labor and output. The horizontal axis shows the self-employment to total employment ratio. Source: LABORSTA (ILO), WEO, authors’ calculations.

Figure III.4. Self-employment and Relative Volatility of Total Employment

Note: The vertical axis shows the ratio of the volatility of cyclical total labor to that of cyclical output. The horizontal axis shows the self-employment to total employment ratio. Source: LABORSTA (ILO), WEO, authors’ calculations.
Figure III.5. Serial Correlation of Output and Informal Labor

First Sample: 1987Q1 - 2003Q2

Second Sample: 2000Q2 - 2010Q4

Note: The figure shows the serial correlation between cyclical output in period $t$ and the cyclical component for each definition of informality in $t+j$, where $j$ is denoted in the horizontal axis. See footnote in Table III.2. for the definitions of each measure of informality.
Note: Each panel shows a rolling window correlation between the cyclical component of output and self-employment (lower panels); and non-self-employed workers (upper panels). Each correlation was computed using 21 quarters, from $t-10$ to $t+10$. The dotted lines represent 95% interval confidence bounds. The two panels on the left refer to the first sample, while the two on the right refer to the second sample. Shaded areas represent recessions according to INEGI.
Figure VI.1. Second Moments and Pass-Through

Panel A. Standard Deviation

Panel B. Correlation with Cyclical Income

Note: Panels A and B reproduce the model-based relative standard deviation and serial correlation with income across various values of $\omega$. Other parameters were calibrated according to Table V.1 and Case I in Table VI.1.
Figure VI.2. Serial Correlation between Income and Informal Labor: Benchmark Cases

Note: CI stands for confidence interval.
Figure VI.3. Impulse Response Functions: Benchmark Case

Note: The Figure displays the cyclical component of the impulse response functions (IRF) of the variables in the model. The units are percentage deviations from steady state. An “I” refers to the informal sector, while an “F” refers to the formal sector. We use the calibration in Case VII in Table VI.1 when computing the IRF. These are generated following a one standard deviation shock in each of the two stochastic processes. In all boxes, except the two in the lower right panels, circles (stars) track the responses of variables following a calibrated one standard deviation shock in the growth (transitory) technology process. In the two lower right panels we report the response of transient and growth productivity processes in both the informal and formal sectors following a shock of stationary and non-stationary nature, respectively.
Figure VII.1. Serial Correlation between Income and Informal Labor: Extensions

Note: CI stands for confidence interval.
Figure VII.2. Impulse Response Functions: Model with Capital Adjustment Cost

Note: See note in Figure VI.3.
### Table III.1. Informality and Business Cycles: Mexico and Canada

<table>
<thead>
<tr>
<th>Moment</th>
<th>Canada</th>
<th>Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma(Y)$</td>
<td>1.63 (.05)</td>
<td>2.32 (.16)</td>
</tr>
<tr>
<td>$\sigma(C) / \sigma(Y)$</td>
<td>0.76 (.04)</td>
<td>1.31 (.09)</td>
</tr>
<tr>
<td>$\sigma(I) / \sigma(Y)$</td>
<td>2.67 (.11)</td>
<td>3.79 (.17)</td>
</tr>
<tr>
<td>$\sigma(NX/Y) / \sigma(Y)$</td>
<td>0.53 (.04)</td>
<td>0.78 (.07)</td>
</tr>
<tr>
<td>$\rho(Y)$</td>
<td>0.93 (.04)</td>
<td>0.81 (.10)</td>
</tr>
<tr>
<td>$\rho(C,Y)$</td>
<td>0.89 (.02)</td>
<td>0.92 (.02)</td>
</tr>
<tr>
<td>$\rho(I,Y)$</td>
<td>0.76 (.05)</td>
<td>0.95 (.01)</td>
</tr>
<tr>
<td>$\rho(NX/Y,Y)$</td>
<td>-0.26 (.14)</td>
<td>-0.82 (.05)</td>
</tr>
<tr>
<td>$\sigma(L) / \sigma(Y)$</td>
<td>0.72 (.04)</td>
<td>0.42 (.04)</td>
</tr>
<tr>
<td>$\rho(L,Y)$</td>
<td>0.90 (.02)</td>
<td>0.54 (.11)</td>
</tr>
</tbody>
</table>

Note: $\sigma(x)$ denotes the standard deviation of the cyclical component of $x$. $\rho(x, y)$ denotes the correlation between the cyclical components of $x$ and $y$. Variables $Y, C, I, NX, L$ stand for output, consumption, investment, net exports and total labor, respectively. Standard deviations are reported in percentages. All the variables were HP-filtered. All variables in logarithms except for the ratio $NX/Y$. Standard errors are reported in parentheses. Moments and their standard errors were computed using GMM. Data from Canada covers from 1981.Q1 to 2002.Q1; Mexican data covers from 1987.Q1 to 2003.Q2.
<table>
<thead>
<tr>
<th>Variable</th>
<th>1987Q1 - 2003Q2</th>
<th>2000Q2 - 2010Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\sigma_i)</td>
<td>(\sigma_i/\sigma_Y)</td>
</tr>
<tr>
<td>(Y)</td>
<td>2.30 (.16)</td>
<td>0.42 (.04)</td>
</tr>
<tr>
<td>(L)</td>
<td>0.98 (.09)</td>
<td>0.78 (.05)</td>
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<td>0.39 (.02)</td>
</tr>
<tr>
<td>(L^8)</td>
<td>2.02 (.02)</td>
<td>0.67 (.03)</td>
</tr>
<tr>
<td>(L^9)</td>
<td>2.58 (.46)</td>
<td>0.85 (.10)</td>
</tr>
<tr>
<td>(L^10)</td>
<td>1.76 (.20)</td>
<td>0.58 (.05)</td>
</tr>
</tbody>
</table>

Note: \(\sigma_i\) refers to the standard deviation (in percentage) of the cyclical component of the variable \(i\). \(\sigma_i/\sigma_Y\) refers to the ratio of volatility between the cyclical component of the \(i\) variable to the volatility of the cyclical component of output. \(\rho(x, z)\) refers to the correlation between the cyclical components of variables \(x\) and \(z\). \(\rho(i, Y|\exp)\) is the correlation between the cyclical components of \(i\) and output, calculated for the periods between troughs and the peaks of the HP-cycle. \(\rho_{\text{NEG}}(i, Y|\text{cont})\) refers to the correlation coefficient calculated for the periods between peaks and trough of the HP-cycle. \(\rho_{\text{NEG}}(i, Y|\exp)\) is similar to \(\rho(x, Y|\exp)\), except that it takes the expansion definition from the official business cycle dates in Mexico. \(\rho_{\text{NEG}}(i, Y|\text{cont})\) keeps that same relation with \(\rho(x, z|\text{cont})\). \(Y\), \(L\) refer to output and labor, respectively. \(L^1\), \(L^2\), \(L^3\), \(L^4\), \(L^5\) refer, respectively, to employment in establishments with 1 to 5 employees; employment not covered by labor legislation benefits; employment from wage earners who do not receive benefits provided by labor legislation; self-employment; and employment in economic units not distinguished to the households. \(L^6\), \(L^7\), \(L^8\), \(L^9\), \(L^10\) refer to the residual when each of the five series on informal labor are subtracted from total employment. The logs of all the data were HP filtered series with a filtering parameter of 1,600. Standard errors are shown in parenthesis.
### Table III.3. Size of the Informal Sector in Mexico

<table>
<thead>
<tr>
<th></th>
<th>Legal and Formal</th>
<th>Legal and Informal</th>
<th>Illegal and Informal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Establishments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[0-5]</td>
<td>4.72</td>
<td>3.40</td>
<td>2.39</td>
</tr>
<tr>
<td>[6-10]</td>
<td>1.15</td>
<td>1.20</td>
<td>1.02</td>
</tr>
<tr>
<td>[+11]</td>
<td>1.28</td>
<td>1.82</td>
<td>1.34</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7.15</td>
<td>6.42</td>
<td>4.75</td>
</tr>
<tr>
<td><strong>Workers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[0-5]</td>
<td>2.81</td>
<td>2.10</td>
<td>1.56</td>
</tr>
<tr>
<td>[6-10]</td>
<td>1.84</td>
<td>1.87</td>
<td>1.59</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>24.07</td>
<td>33.68</td>
<td>23.42</td>
</tr>
<tr>
<td><strong>Capital</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[0-5]</td>
<td>1.82</td>
<td>1.29</td>
<td>1.37</td>
</tr>
<tr>
<td>[6-10]</td>
<td>1.05</td>
<td>1.13</td>
<td>1.14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>29.37</td>
<td>39.52</td>
<td>31.45</td>
</tr>
<tr>
<td><strong>Value Added</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[0-5]</td>
<td>2.00</td>
<td>1.48</td>
<td>1.5</td>
</tr>
<tr>
<td>[6-10]</td>
<td>1.38</td>
<td>1.52</td>
<td>1.15</td>
</tr>
<tr>
<td>[+11]</td>
<td>25.14</td>
<td>40.02</td>
<td>30.02</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>28.51</td>
<td>43.02</td>
<td>32.67</td>
</tr>
</tbody>
</table>

Note: Numbers show the share of establishments, inputs (labor and capital) and value added that are allocated to each type of firm disaggregating by formality and legality status and firm size for three different years. For example, in 2008, 20.27 percent of all workers belonged to legal and formal firms of more than 11 workers while 23.6 percent did to firms with 5 or less workers that were also legal but informal. For more information about the definitions and details see the text and Busso et al. (2012). Source: Busso et al. (2008).

### Table III.4. Average Permanence in Formality by Mexican Workers

<table>
<thead>
<tr>
<th>Years in Formality</th>
<th>All</th>
<th>Always High</th>
<th>Always Low</th>
<th>Low/High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>23.9</td>
<td>15.8</td>
<td>44.0</td>
<td>6.3</td>
</tr>
<tr>
<td>4-6</td>
<td>19.4</td>
<td>14.4</td>
<td>22.6</td>
<td>19.2</td>
</tr>
<tr>
<td>7-9</td>
<td>23.7</td>
<td>18.3</td>
<td>17.2</td>
<td>34.9</td>
</tr>
<tr>
<td>10</td>
<td>33.1</td>
<td>51.6</td>
<td>16.2</td>
<td>39.5</td>
</tr>
</tbody>
</table>

Note: Numbers show the percentage of years spent in formality by Mexican workers during a 10 year period (1997-2006). The workers are divided by wage level into those who earned high wages, low wages, and those who earned both low and high wages during the period. Source: Levy (2008).
Table V.1. Calibrated Parameters and Long Run Shares

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e$</td>
<td>Elasticity of substitution between F and I goods $(1/1-e)$</td>
<td>0.875</td>
<td>Restrepo-Echavarria (2011)</td>
</tr>
<tr>
<td>$\tau^w$</td>
<td>Tax on wage bill</td>
<td>0.1142</td>
<td>Methodology by Mendoza et al. (1994)</td>
</tr>
<tr>
<td>$\tau'$</td>
<td>Tax on income</td>
<td>0.0722</td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Formal capital share</td>
<td>0.35</td>
<td>Garcia-Verdu (2005)</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Intertemporal Elasticity of substitution $(1/\sigma)$</td>
<td>2</td>
<td>Aguiar and Gopinath (2007)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation rate (quarterly)</td>
<td>0.05</td>
<td>Aguiar and Gopinath (2004)</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Wage elasticity of labor supply</td>
<td>1.6</td>
<td>Aguiar and Gopinath (2004)</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Interest rate debt elasticity</td>
<td>0.00001</td>
<td>Schmitt-Grohe and Uribe (2003)</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Long run productivity growth factor (quarterly)</td>
<td>1.006</td>
<td>Data. Average GDP growth.</td>
</tr>
<tr>
<td>$R$</td>
<td>External Interest Rate (quarterly)</td>
<td>1.0145</td>
<td>Data by Uribe and Yue (2005)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount rate</td>
<td>0.9976</td>
<td>Satisfies the steady state condition: $1=R\beta\mu^\alpha$</td>
</tr>
<tr>
<td>$\alpha_i$</td>
<td>Informal capital share</td>
<td>0.20</td>
<td>Restrepo-Echavarria (2011)</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Productivity gap between formal and informal technology</td>
<td>0.0198</td>
<td>Using micro data from Busso et al. (2012)</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Share of formal goods in aggregate consumption</td>
<td>0.2791</td>
<td>Pinned down by satisfying an $h'$ share of 0.3514</td>
</tr>
<tr>
<td>$d$</td>
<td>Steady state debt to (formal) income</td>
<td>0.10</td>
<td>Aguiar and Gopinath (2007)</td>
</tr>
<tr>
<td>$\rho_a$</td>
<td>Persistence of transient technology</td>
<td>0.94</td>
<td>Aguiar and Gopinath (2004)</td>
</tr>
<tr>
<td>$\rho_g$</td>
<td>Persistence of growth shock</td>
<td>0.72</td>
<td>Aguiar and Gopinath (2004)</td>
</tr>
<tr>
<td>$\omega$</td>
<td>Pass-through of shocks from F to I</td>
<td>varies</td>
<td></td>
</tr>
<tr>
<td>$\sigma_a$</td>
<td>Standard deviation of transient technology shock</td>
<td>varies</td>
<td></td>
</tr>
<tr>
<td>$\sigma_g$</td>
<td>Standard deviation of growth shock</td>
<td>varies</td>
<td></td>
</tr>
</tbody>
</table>

Note: The period is a quarter in our calibration. See the text for an explanation of the strategy to calibrate $\omega$, $\sigma_a$, and $\sigma_g$ and the various results obtained with different values for these parameters.
### Table VI.1. Business Cycle Moments

<table>
<thead>
<tr>
<th></th>
<th>Case I</th>
<th>Case II</th>
<th>Case III</th>
<th>Case IV</th>
<th>Case V</th>
<th>Case VI</th>
<th>Case VII</th>
<th>Case VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calibrated Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.95*</td>
<td>0.05*</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>$100^* \sigma_a$</td>
<td>0.41*</td>
<td>0.41*</td>
<td>0.41*</td>
<td>0.04</td>
<td>0.01</td>
<td>0.01</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>$100^* \sigma_g$</td>
<td>1.09*</td>
<td>1.09*</td>
<td>1.09*</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>$\sigma_a / \sigma_g$</td>
<td>0.38</td>
<td>0.38</td>
<td>0.38</td>
<td>0.14</td>
<td>0.03</td>
<td>0.03</td>
<td>0.14</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>RWC</strong></td>
<td>5.27</td>
<td>5.27</td>
<td>5.27</td>
<td>6.00</td>
<td>6.14</td>
<td>6.14</td>
<td>6.00</td>
<td>5.73</td>
</tr>
<tr>
<td>$\sigma_a / \sigma_g$ in AG (2007)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Second Moments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma(Y)$</td>
<td>2.42</td>
<td>8.80</td>
<td>19.29</td>
<td>9.48</td>
<td>2.41</td>
<td>2.37</td>
<td>2.37</td>
<td>2.41</td>
</tr>
<tr>
<td>$\sigma(C)/\sigma(Y)$</td>
<td>1.30</td>
<td>1.11</td>
<td>0.76</td>
<td>1.09</td>
<td>1.17</td>
<td>1.18</td>
<td>1.17</td>
<td>1.17</td>
</tr>
<tr>
<td>$\sigma(I)/\sigma(Y)$</td>
<td>3.86</td>
<td>7.70</td>
<td>7.13</td>
<td>8.17</td>
<td>7.89</td>
<td>7.84</td>
<td>7.84</td>
<td>7.89</td>
</tr>
<tr>
<td>$\sigma(TBY)/\sigma(Y)$</td>
<td>0.81</td>
<td>2.31</td>
<td>1.98</td>
<td>2.42</td>
<td>2.36</td>
<td>2.35</td>
<td>2.35</td>
<td>2.36</td>
</tr>
<tr>
<td>$\rho(Y)$</td>
<td>0.82</td>
<td>0.94</td>
<td>0.95</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
</tr>
<tr>
<td>$\rho(Y,C)$</td>
<td>0.92</td>
<td>0.92</td>
<td>0.97</td>
<td>0.95</td>
<td>0.96</td>
<td>0.97</td>
<td>0.97</td>
<td>0.96</td>
</tr>
<tr>
<td>$\rho(Y,I)$</td>
<td>0.96</td>
<td>0.25</td>
<td>0.26</td>
<td>0.21</td>
<td>0.23</td>
<td>0.24</td>
<td>0.24</td>
<td>0.23</td>
</tr>
<tr>
<td>$\rho(Y,TBY)$</td>
<td>-0.86</td>
<td>-0.12</td>
<td>-0.04</td>
<td>-0.09</td>
<td>-0.13</td>
<td>-0.14</td>
<td>-0.14</td>
<td>-0.13</td>
</tr>
<tr>
<td>$\sigma(h)/\sigma(Y)$</td>
<td>0.43</td>
<td>0.29</td>
<td>0.14</td>
<td>0.26</td>
<td>0.20</td>
<td>0.19</td>
<td>0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>$\rho(Y,h)$</td>
<td>0.60</td>
<td>0.75</td>
<td>0.05</td>
<td>0.73</td>
<td>0.67</td>
<td>0.67</td>
<td>0.67</td>
<td>0.67</td>
</tr>
<tr>
<td>$\sigma(h)/\sigma(Y)$</td>
<td>0.56</td>
<td>0.40</td>
<td>0.67</td>
<td>0.43</td>
<td>0.33</td>
<td>0.30</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>$\rho(Y,h')$</td>
<td>0.75</td>
<td>0.76</td>
<td>1.00</td>
<td>0.83</td>
<td>0.83</td>
<td>0.84</td>
<td>0.84</td>
<td>0.83</td>
</tr>
<tr>
<td>$\rho(Y,h')$</td>
<td>-0.46</td>
<td>0.17</td>
<td>-0.98</td>
<td>-0.45</td>
<td>-0.42</td>
<td>-0.41</td>
<td>-0.41</td>
<td>-0.42</td>
</tr>
</tbody>
</table>

Note: A "*" denotes that $\omega$ was set manually for experiment described in main text. A "+" denotes that the parameter was calibrated based upon Aguiar and Gopinath (2004). Other parameters were calibrated based upon a minimization of the distance between the model-based moments and the data. In each Case a different subset of moments was used. See text for details. The model-based moments refer to formal aggregates unless otherwise stated. Both data and model-based second moments are computed using the HP-filter.
**Table VII.1. Business Cycle Moments: Extensions**

<table>
<thead>
<tr>
<th></th>
<th>Extension I</th>
<th>Extension II</th>
<th>Extension III</th>
<th>Extension IV</th>
<th>Extension V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calibrated Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.50</td>
<td>0.50</td>
<td>0.65</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>$\omega_a$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>$\omega_g$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.60</td>
</tr>
<tr>
<td>$\phi$</td>
<td>0.21</td>
<td>0.21</td>
<td>0.01</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>$100^*\sigma_a$</td>
<td>0.13</td>
<td>0.13</td>
<td>0.24</td>
<td>0.13</td>
<td>0.17</td>
</tr>
<tr>
<td>$100^*\sigma_g$</td>
<td>0.36</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.32</td>
<td>0.36</td>
</tr>
<tr>
<td>$\sigma_a/\sigma_g$</td>
<td>0.35</td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.39</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>$RWC$</strong></td>
<td>5.36</td>
<td>0.00</td>
<td>0.00</td>
<td>5.19</td>
<td>4.92</td>
</tr>
<tr>
<td>$\sigma_a/\sigma_g$ in AG (2007)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.38</td>
</tr>
<tr>
<td>$RWC$ in AG (2007)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.73</td>
</tr>
<tr>
<td><strong>Second Moments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma(Y)$</td>
<td>2.42</td>
<td>2.35</td>
<td>0.89</td>
<td>2.40</td>
<td>2.06</td>
</tr>
<tr>
<td>$\sigma(C)/\sigma(Y)$</td>
<td>1.30</td>
<td>1.28</td>
<td>0.63</td>
<td>0.60</td>
<td>1.15</td>
</tr>
<tr>
<td>$\sigma(I)/\sigma(Y)$</td>
<td>3.86</td>
<td>4.48</td>
<td>4.11</td>
<td>7.00</td>
<td>4.45</td>
</tr>
<tr>
<td>$\sigma(TBY)/\sigma(Y)$</td>
<td>0.81</td>
<td>1.33</td>
<td>0.94</td>
<td>1.95</td>
<td>1.36</td>
</tr>
<tr>
<td>$\rho(Y)$</td>
<td>0.82</td>
<td>0.98</td>
<td>0.96</td>
<td>0.95</td>
<td>0.97</td>
</tr>
<tr>
<td>$\rho(Y,C)$</td>
<td>0.92</td>
<td>0.94</td>
<td>0.99</td>
<td>0.99</td>
<td>0.95</td>
</tr>
<tr>
<td>$\rho(Y,I)$</td>
<td>0.96</td>
<td>0.72</td>
<td>0.69</td>
<td>0.28</td>
<td>0.73</td>
</tr>
<tr>
<td>$\rho(Y,TBY)$</td>
<td>-0.86</td>
<td>-0.56</td>
<td>-0.32</td>
<td>-0.01</td>
<td>-0.56</td>
</tr>
<tr>
<td>$\sigma(h)/\sigma(Y)$</td>
<td>0.43</td>
<td>0.22</td>
<td>0.50</td>
<td>0.44</td>
<td>0.25</td>
</tr>
<tr>
<td>$\rho(Y,h)$</td>
<td>0.60</td>
<td>0.38</td>
<td>1.00</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>$\sigma(h)/\sigma(Y)$</td>
<td>0.56</td>
<td>0.28</td>
<td>0.69</td>
<td>0.72</td>
<td>0.32</td>
</tr>
<tr>
<td>$\rho(Y,h)$</td>
<td>0.75</td>
<td>0.63</td>
<td>1.00</td>
<td>1.00</td>
<td>0.63</td>
</tr>
<tr>
<td>$\rho(h)^2/\sigma(Y)$</td>
<td>1.07</td>
<td>0.27</td>
<td>0.20</td>
<td>0.14</td>
<td>0.28</td>
</tr>
<tr>
<td>$\rho(Y,h')$</td>
<td>0.75</td>
<td>0.63</td>
<td>1.00</td>
<td>1.00</td>
<td>0.63</td>
</tr>
<tr>
<td>$\rho(Y,h')$</td>
<td>-0.46</td>
<td>-0.31</td>
<td>0.82</td>
<td>-0.46</td>
<td>-0.26</td>
</tr>
</tbody>
</table>

Note: a “+” denotes that the parameter was manually set to zero for experiment described in main text. Other parameters were calibrated based upon a minimization of the distance between the model-based moments and the data. In each extension a different subset of moments was used. See text for details. The model-based moments refer to formal aggregates unless otherwise stated. Both data and model-based second moments are computed using the HP-filter.