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Informality, Labor Regulation, and the Business Cycle

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Abstract: We analyze the joint impact of employment protection and informality on macroeconomic volatility and the propagation of shocks in emerging economies. For this, we propose a small open economy business cycle model with frictional labor markets, labor regulation, and an informal sector, modeled as self-employment. The model is calibrated to the Mexican economy, in particular to business cycle moments for employment and informality obtained from our own calculations with the ENOE survey for the period 2005-2016. We show that international interest rate shocks, which affect specifically job creation in the formal sector, are key to obtain a counter-cyclical informality rate. In our model both the economy without an informal sector and the economy with informality but a lower burden of labor regulation feature higher volatility in employment but smaller fluctuations in TFP and output.

Keywords: informality, business cycle, small open economy, job creation, employment protection, international interest rate shocks

JEL Classification: E24, E32, F44, J65

Resumen: Analizamos el impacto conjunto de la protección laboral y la informalidad en la volatilidad macroeconómica y en la propagación de choques en economías emergentes. Para esto, proponemos un modelo de economía pequeña y abierta con fricciones en el mercado laboral, regulación laboral y un sector informal, modelado como autoempleo. El modelo es calibrado para la economía mexicana, en particular, usando momentos de empleo e informalidad obtenidos a partir de nuestros propios cálculos con la ENOE en el periodo 2005-2016. Mostramos que choques a la tasa de interés internacional, que afectan específicamente a la creación de empleo en el sector formal, son clave para obtener una tasa de informalidad contracíclica. En nuestro modelo tanto una economía sin sector informal como una economía con sector informal pero menor regulación laboral en el sector formal exhiben una mayor volatilidad en el empleo pero menores fluctuaciones en el producto y en la productividad total de factores.

Palabras Clave: informalidad, ciclo económico, economía pequeña y abierta, creación de empleo, protección laboral, choques de tasa de interés internacional

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1 Introduction

Business cycles in emerging economies feature high output volatility and relatively low employment volatility. Table 1 highlights these two features for a set of countries. The volatility of GDP is almost 75 percent as large in the sample of emerging economies compared to developed countries; however, relative to output, employment fluctuations are in fact smaller.

This observation points to a key difference between emerging and developed economies: the work of labor markets. Table 1 also documents that emerging economies face more restrictive labor regulations, measured as a larger number of weeks of wages paid by firms in the event of a separation. However, another important difference across labor markets is the incidence of the informal sector. The last two columns of Table 1 show that, perhaps in response to the more rigid labor regulation and a weak enforcement of it, the size of the informal sector is much larger in emerging economies.

Emerging economies also feature some distinctive cyclical properties of occupational categories. We use Mexico as a benchmark country for our analysis due to the high incidence of informality and the availability of detailed data on labor flows in the period 2005-2016. In the empirical section, we show that the informality rate (informal employment as a fraction of total employment) is counter-cyclical. However, we challenge the notion that this implies a reallocation of workers between the formal and informal sectors over the business cycle. Informal employment, calculated as percentage of the working-age population, is basically acyclical in the period 2005-2016, while the pro-cyclicality of the (total) employment to population ratio is driven by movements in and out of the labor force.

All these facts point to a potentially different mechanism of adjustment of the labor input over the business cycle in emerging economies. The objective of the paper is to understand this mechanism and assess its impact on business cycle volatilities and the propagation of

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shocks in an economy characterized by high degrees of employment protection and informality.

For this, we build a simple business cycle model for a small open economy, with aggregate technology and international interest rate shocks. The model features both formal and informal sectors, the latter modeled as a self-employment option, labor market frictions and employment protection in the formal sector (introduced as firing costs), and an endogenous participation in the labor force decision. We calibrate the model to aggregate data for Mexico and show that the model is consistent with the business cycle properties of different occupational categories. In particular, the model replicates very well the counter-ciclicality of the informality rate in the period 2005-2016, even with symmetric technology shocks. Moreover, the fluctuations in the informality rate are driven by changes in job creation in the formal sector, as suggested by the empirical evidence for Mexico.

In the model, the cyclical properties of the informality rate depend on the shocks affecting the economy. A negative technology shock, affecting symmetrically both sectors, reduces total employment and GDP but has almost no impact on the informality rate. In contrast, an exogenous increase in the international interest rate also has a contractionary effect, but only to the formal sector. The mechanism is a fall in the present value of a job for a formal entrepreneur through the increase in the rate at which future payoffs are discounted, disincentivizing vacancy posting.[1] The key assumption, supported by the evidence, is that because of labor regulation formal employment entails a long term relationship, while informal employment is more flexible and basically can be modeled as a static decision. The interaction between the two shocks allows us to account for a counter-cyclical informality rate driven by the cyclicality of formal employment, instead of the fluctuations in informal employment.[2]

Using the model, we ask two related questions: Given the labor regulation, to which extent the informal sector makes the labor market more "flexible" along the business cycle?

[1] Hall (2017) uses a similar argument to explain why unemployment rises in the U.S. when the discount rate implicit in the stock market rises.

[2] Another implication of this mechanism is that the international interest rate is counter-cyclical, as observed in the data, even though we assume independent processes for the two aggregate shocks. Because of this, consumption in the model is more volatile than output, matching a well known regularity in emerging economies.

	$\sigma(y)$	$\sigma(l)/\sigma(y)$	Empl. Protection		Informality	
	(percent)		D.B.I.	H&P	I.L.O.	Schneider (2007)
Emerging Economies						
Argentina	3.86	0.63	23	12	49.7	29.9
Brazil	1.75	0.58	9	7	42.2	42.3
Chile	1.95	0.65	12	14	33.1	20.9
Colombia	1.91	0.75	19	15	52.2	43.4
Mexico	2.43	0.45	22	13	34.1	33.2
Average	2.38	0.61	17	12	42.3	33.9
Developed Economies						
Australia	1.20	0.96	8	2	–	13.5
Canada	1.45	0.72	5	2	–	15.2
Norway	1.43	0.57	0	4	–	12.3
New Zealand	1.37	0.91	0	1	–	18.4
United Kingdom	1.39	0.74	3	6	–	12.2
Average	1.37	0.78	3	3	–	14.3

Notes: This table is taken from Lama and Urrutia (2011). The first two columns are constructed using quarterly data from Haver Analytics from 1980 to 2013. The sample period varies for each country according to all available data. All these series are detrended using the Hodrick-Prescott filter. The volatilities of GDP and employment are denoted by $\sigma(y)$ and $\sigma(l)$. The World Bank's set of Doing Business Indicators (D.B.I.) include a measure of the cost of severance payments due for firing a worker, averaged across workers of different tenure. The Heckman and Pagés-Serra (2000) indicator (H&P) measures the costs of advance notice and compulsory severance payments expressed in present value. The informality measures reported in this table are obtained for different countries from the International Labor Organization (I.L.O.), as a percentage of the labor force, and from Schneider (2007), as a percentage of GDP. The hyphen means the figure is not available for the country.

Table 1: Business Cycle Properties, Employment Protection, and Informality Across Countries

And, what are the effects on the informal sector and the business cycle of reducing the burden of labor regulation? We show that, confronted with similar shocks, the economy without an informal sector features higher volatility in total employment and consumption, but smaller fluctuations in measured total factor productivity (TFP) and output. In that sense the informality option provides a margin of adjustment to shocks in the presence of a stringent labor regulation at a cost in terms of TFP volatility.

With respect to the second question, an economy with lower costs of formality (less employment protection and/or low payroll taxes) would feature in steady state a larger employment rate and a smaller informality rate. The long run TFP effects of reducing the size of the informal sector would be large, around 5% to 6%. Moreover, this economy would exhibit

larger volatility in employment but smaller TFP fluctuations. The productivity effects are large enough so that the economy with low employment protection features also lower output volatility. The results of the exercise are broadly consistent with the differences between emerging and developed economies documented in Table 1.

Our analysis borrows from a recent literature focusing on informality and business cycles. Restrepo-Echavarria (2014) and Fernández and Meza (2015) use two sector models with competitive labor markets and argue that the reallocation between the formal and informal sectors is important to understand business cycles in emerging economies. A negative technology shock in the formal sector reduces formal employment but this impact is partially offset by an increase in the size of the informal sector, which acts as a buffer for total employment.[3] Notice that the mechanism requires different technology shocks to the formal and informal sectors, as these papers assume.[4]

None of the previous models allow for unemployment, as labor markets are assumed to be competitive. Albrecht et al. (2009) add an informal sector to a standard search and matching model and analyze the impact of labor market policies, but only on steady-state outcomes. Bosch and Esteban-Pretel (2012) use a Mortensen-Pissarides matching model of the labor market with formal and informal jobs to analyze job creation and job destruction over the business cycle. Finkelstein Shapiro (2014) focus on the self-employment component of informality and argues that the presence of idle resources in recessions favors a recovery led by self-employed workers. Finally, some recent models add occupational choice and/or firm dynamics to capture the heterogeneity of workers and firms between and within the formal and informal sectors.[5]

[3] As in the literature of home production, this class of models distinguish between measured and unmeasured output, consumption, and labor. The assumption is that the National Income and Product Accounts do not observe the informal counterparts of these variables, nor do they make any effort in estimating them. This is key to match with the model the excess volatility of these variables in economies with larger informal sectors (see Conesa et al., 2002). Our analysis does not rely on that assumption; in fact, we take the opposite view that all output in the informal sector is accounted for in GDP.

[4] Horvath (2018) adds to these two models interest rate shocks and a working capital constraint to the purchase of labor services. The asymmetry comes from the assumption that only firms in the formal sector have access to credit and face this constraint, while informal firms do not use working capital.

[5] See, for instance, Amaral and Quintin (2006), D'Erasmo and Moscoso Boedo (2012), Leal (2014), and Lopez-Martin (2016). The main goal of these models is to generate TFP losses out of size-dependent distortions and financial frictions in the presence of an informal sector. Their focus is again on steady-state outcomes only.

The paper is organized as follows. In section 2 we document the cyclical properties of employment and informality in Mexico, using our own calculations using the national labor market survey. In Section 3 we build a model of business cycles for a small open economy, adding labor market frictions and self-employment. The model is calibrated in Section 4 and its business cycle properties are compared to the data. Section 5 uses the model to discuss the relation between employment protection, informality, and business cycle fluctuations. Finally, we conclude.

2 Informality and the Business Cycle in Mexico, 2005-2016

We begin our analysis by documenting some cyclical properties of employment and informality in Mexico using our own elaboration on the data from the national labor market survey. Using a quarterly sample for the period 2005-2016, we document that the (total) employment to population ratio is highly pro-cyclical, informal employment (expressed as percentage of the working-age population) is acyclical, and the informality rate (defined as the share of informal workers over total employment) is counter-cyclical. We also assess the importance of movements in and out of the labor force in accounting for the dynamics of employment.

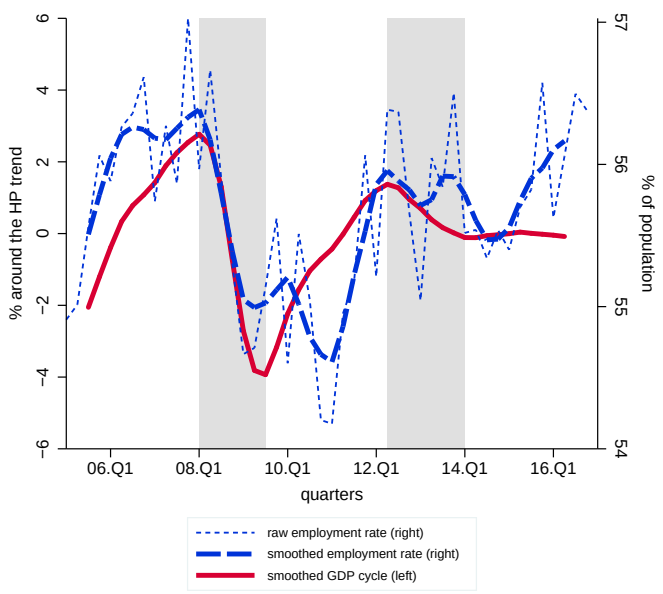
2.1 Occupational Categories in the ENOE Survey

We use the Encuesta Nacional de Ocupación y Empleo (ENOE), a national representative household survey which is the source of key labor market variables in Mexico. Using weighted data at the respondent level, we classify people in four occupational categories: Formal workers, informal workers, unemployed, and out of the labor force.[6] All these categories are expressed as a fraction of working-age population (aged 15 and over), excluding employed individuals reporting zero earnings (non-earner workers).[7]

[6] Informal workers are here defined as people working for an unregistered business and/or under conditions of informality (i.e., if the employer does not provide for health insurance coverage).

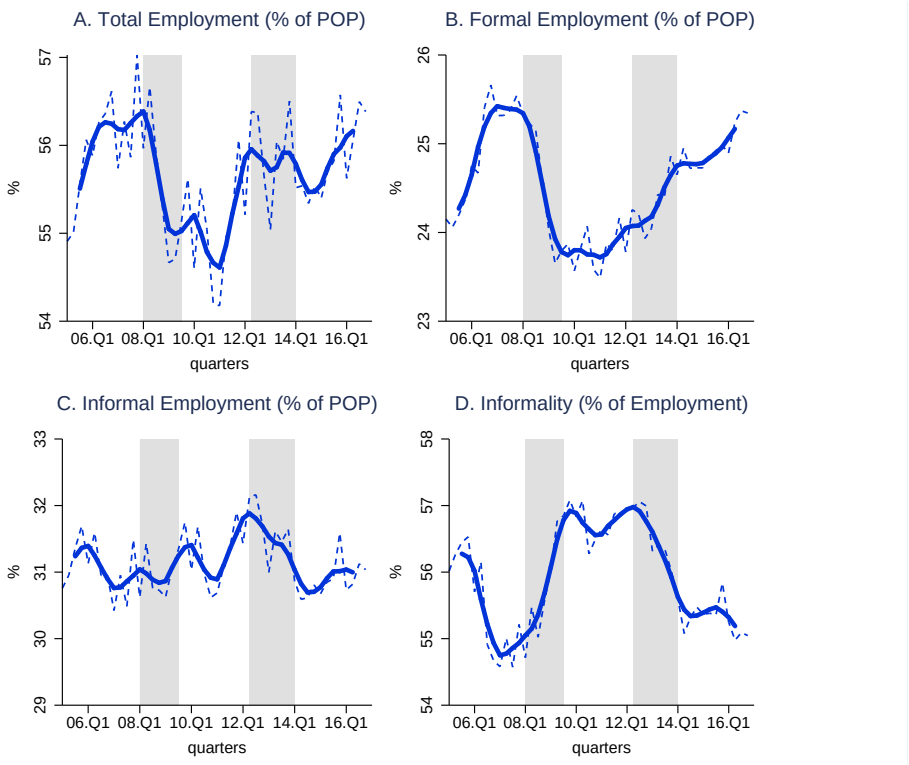
[7] We note that in the first two employment categories we are including both wage-earners and self-employed workers. The formal employment category includes very few self-employed workers (about 14%). However, 41% of informal workers are self-employed.

Figure 1: Employment Rate and the Business Cycle in Mexico, 2005-2016



Notes: This figure shows the comovement between the cyclical component of the Mexican gross domestic product or GDP (as estimated by INEGI, the national statistics agency) and the employment to (working-age) population ratio (own calculation using the ENOE survey and excluding non-earner workers) over two episodes of contraction in the period 2005.Q1-2016.Q4. Both the GDP and the employment rate are smoothed out using the centered to moving average to clean up for seasonality. The GPD cycle is obtained from the smoothed series using the Hodrick-Prescott or HP filter with parameter 1600. The two downturns (shaded) correspond roughly to the global financial crisis and the mild though long domestic contraction. We define the start and end of each episode by looking at the peaks and troughs of each phase of the cycle. The recession is dated from 2008.Q1 to 2009.Q2 and the mild contraction is dated from 2012.Q2 to 2013.Q4. See Banco de México's Quarterly Report of July-September of 2014, Box 1, pages 21-24, for a discussion about the second episode.

Figure 2: Employment and Informality Rates



Notes: This figure displays four employment rates to highlight the role of informal employment over two episodes of contraction (shaded) in the period 2005.Q1-2016.Q4. All employment rates are expressed as percentage of the working-age population (POP). Raw (dashed) and smoothed (solid) rates are shown. Own calculations using the ENOE survey and excluding non-earner workers.

For each of these variables we compute quarterly time series from 2005.Q1 to 2016.Q4, the longest time period covered by the ENOE. We also construct two additional variables: (i) the *employment rate*, defined as total employment (formal and informal) over population and measuring the aggregate labor input in the economy; and (ii) the *informality rate*, defined as informal employment over total employment and measuring the share of employed workers in the informal sector. On average, the employment rate in our sample is 55.7%, while the informality rate is 55.9%.

2.2 Employment, Informality, and the Business Cycle

Figure 1 plots the evolution of the employment rate against the cyclical component of GDP. In our sample we identify two downturns, a recession in 2008-2009 corresponding to the world financial crisis and a milder fall in 2012-2013 (see the shaded areas). In the first downturn the employment rate falls by about 1.5 percentage points while in the second downturn the drop in employment amounts to half of a percentage point of the working-age population. Figure 2 decomposes the evolution of the employment rate between formal and informal employment, including both wage-earners and self-employed. Looking at panels B and C, we can see that the fall in employment in the 2008-2009 recession is mostly driven by a decline in formal employment, while the fall in employment in the 2012-2013 downturn is almost entirely driven by a decline in informal employment. Therefore, as shown in panel D, the informality rate increases in the first downturn but falls in the second.

2.3 Business Cycle Properties

Table 2 reports the cross-correlation and relative variability with respect to GDP of the occupational categories and the employment and informality rates. When available, we report the comparable statistics for the U.S. As expected, total employment in Mexico is highly procyclical. It is also about as half as volatile as GDP, which is less than the relative volatility of employment in the U.S. (about three-fourths). In the context of a model, we will show later that employment protection together with the presence of an informal sector option might

	Mexico						U.S.	
X	σ_X/σ_Y	Y_{-2}	Y_{-1}	Y	Y_{+1}	Y_{+2}	σ_X/σ_Y	Y
GDP (Y)	1.00	0.71	0.92	1.00	0.92	0.70	1.00	1.00
Employment rate (% of POP)	0.42	0.63	0.73	0.76	0.69	0.49	0.72	0.83
Informal employment (% of POP)	0.52	-0.03	-0.00	0.06	0.11	0.13	-	-
Informality rate (% of employment)	0.53	-0.56	-0.61	-0.56	-0.43	-0.26	-	-
- Working for wages	0.66	-0.29	-0.33	-0.39	-0.42	-0.36	-	-
- Self-employed	0.90	-0.45	-0.47	-0.36	-0.17	0.00	-	
Out of labor force (% of POP)	0.42	-0.32	-0.39	-0.46	-0.48	-0.39	0.19	-0.21
Unemployment rate (% of labor force)	3.74	-0.80	-0.93	-0.92	-0.76	-0.50	8.54	-0.84

Notes: All the series for Mexico are smoothed out using centered moving averages to clean up for seasonality and detrended using the Hodrick-Prescott filter with parameter 1600. Correlation figures for the U.S. are taken directly from Table 1 in Krusell et al. (2017) for the period 1978.Q1-2012.Q3, while relative standard deviations are implied by the same table using a standard deviation of output of 0.0137, which is our calculation using data from the Bureau of Economic Analysis (NIPA Table 1.1.6, seasonally adjusted chained dollars of 2012). POP stands for working-age population.

Table 2: Business Cycle Statistics: Mexico, 2005.Q1-2016.Q4

mitigate the volatility of employment, offering a potential explanation for this difference.

Table 2 also shows that informal employment (as a fraction of population) varies almost regardless of the stance of the economy. The informality rate (as a fraction of total employment) thus moves in the opposite direction as output does along the business cycle as a result of the high pro-cyclicality of total employment and the acyclicity of informal employment (see again Figures 1 and 2).[8] Notice that the cyclical properties of the informality rate are similar for informal wage-earners and self-employed workers.[9]

The incidence of informality may also reflect on the business cycle properties of the two non-employment categories: out of labor force rate and the unemployment rate. To see this, we also report the counterpart cross-correlations and standard deviations for the U.S. The out

[8] In a previous study, Fernández and Meza (2015) report a large set business cycle statistics for employment in the Mexican economy, with data obtained from ENEU (for the period 1987-2004) and from ENOE, together with ENE or Encuesta Nacional de Empleo (for 2000-2010). In both samples, the employment rate is pro-cyclical, featuring a correlation with GDP of about 0.55. However, the informality rate is counter-cyclical in both samples. Alonso-Ortiz and Leal (2017) and Alcaraz et al. (2015) also show that the informality rate is counter-cyclical and, in particular, increased during the 2008-2009's Great Recession. In Appendix A we show that the counter-cyclicality of the informality rate does not seem to be driven by composition changes in the employed population across some selected demographic variables.

[9] In Table 7 from Appendix C we provide the same statistics computed using an older sample (1987-2004) from the former Encuesta Nacional de Empleo Urbano (ENEU). This labor survey only covered urban areas. Notice though that the results are qualitatively similar to those reported in Table 2, obtained from the ENOE.

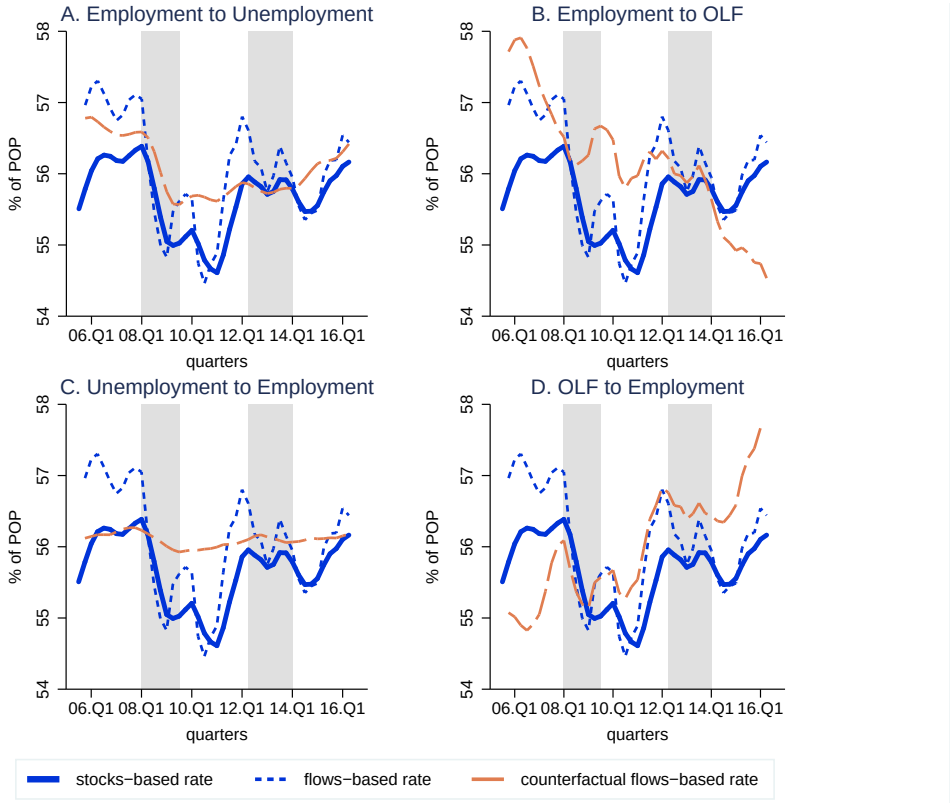
of the labor force rate in Mexico is twice as much volatile as in the U.S., possibly as a result of frequent transitions between this labor market state and the informal sector (see Bosch and Maloney, 2008). The contrary happens with the unemployment rate, which is almost half as volatile in Mexico than in the U.S. Thus, unemployment in Mexico could be serving less as a buffer against cyclical shocks, possibly relegating such a role to the informal sector though with some lags. Note the slight increase in informal employment at the end of the Great Recession in Figure 2 (see shaded area in panel C).

2.4 Gross Flows and the Employment Rate

To further highlight this point, we analyze in more detail gross flows using the transition rates between occupational categories, calculated by taking advantage of the panel structure of the ENOE survey.[10] Based on these transition rates, Figure 3 reports the contribution of gross flows in and out of total employment (job creation and job destruction) to the actual employment rate. For instance, panel A compares the observed employment rate (shown in two alternative series) to the counterfactual employment rate that we would observe keeping all transition rates constant over time *except* for the gross flows from employment (formal or informal) to unemployment.

[10] This survey is a rotating panel that follows the same households (allowing for proxy responses) in 5 consecutive quarters. We are left with 88% of the sample in average in the period 2005-2016 after linking respondents in two consecutive quarters. We use geographic (house, state, place of birth, locality) as well as demographic (sex, age, education, age) variables as identifiers to match people. In the construction of the transition rates we have benefited from Robert Shimer's Stata do files available at his personal website. We could not perform the correction of the aggregation bias discussed in Shimer's paper because the eigenvalues of the transition matrix were complex numbers. See Shimer (2012) for additional details on the cases where his procedure is not implementable.

Figure 3: Transitions and the Employment Rate: Job Creation and Destruction



Notes: This figure presents the results of a decomposition by comparing in each panel three employment rates over two episodes of contraction (shaded) in the period 2005.Q1-2016.Q4. The solid blue line ("stocks-based rate") stands for the smoothed employment rate reported before in Figures 1 and 2. The short-dashed blue line ("flows-based rate") is the employment rate as implied by the composition of gross flows among 5 occupational categories: formal employed, informal wage-earner, informal self-employed, unemployed, and inactive (OLF). We calculate all twenty-five gross flows by following Shimer (2012)'s methodology. The reason why these two employment rates differ, though slightly, is the attrition in the construction of these gross flows. The third employment rate is a counterfactual rate (shown in long-dashed orange), the one we would observe had a specific gross flow, say from OLF to employment as in panel D, been the only one allowed to vary (being active) throughout the period while keeping the rest of flows equal to their corresponding sample averages (inactive). The "counterfactual flows-based rate" in each panel is intended to weigh the role of the corresponding active gross flow (see titles in each panel) in shaping the cyclicality of the observed employment rate. All rates are expressed as percentage of population (POP). Own calculations using the ENOE and excluding non-earner workers.

One important finding is that movements in and out of the labor force (second column of Figure 3) are the key drivers of the employment rate. Only in the first recession do movements from employment to unemployment account for about half of the decline in the employment rate, while transitions from unemployment to employment play no significant role. The other important finding is that job creation (from OLF) is the main driver of the increase in employment during the recoveries.[11]

[11] We are missing the transitions taking place within a quarter, so these results hold to the extent of this caveat.

Volatility and correlation with GDP	σ_X	Y_{-2}	Y_{-1}	Y	Y_{+1}	Y_{+2}
International interest rate $(1+i^*)$	0.52	-0.02	-0.19	-0.30	-0.32	-0.26
Correlation with international interest rate		$1+i^*_{-2}$	$1+i^*_{-1}$	$1+i^*$	$1+i^*_{+1}$	$1+i^*_{+2}$
Counterfactual employment rate, only flows from OLF						
- to formal employment		-0.15	-0.19	-0.19	-0.09	0.05
- to total employment		0.09	0.09	0.01	-0.07	-0.12
Counterfactual informality rate, only flows from OLF						
- to formal employment		0.15	0.19	0.19	0.09	-0.05

Notes: Own calculations using the ENOE survey and our own construction of the international interest rate using the 90-day T-bill rate plus the EMBI spread, minus the U.S. inflation based on the GDP deflator.

Table 3: International Interest Rates and Business Cycles: Mexico, 2005.Q1-2016.Q4

2.5 International Interest Rates and Job Creation

One important mechanism in our model will be the impact of international interest rate shocks on job creation, in particular in the formal sector. According to the story sketched in the introduction, an increase in international interest rates decreases the value of a match for formal entrepreneurs, reducing vacancy posting and job creation. Everything else equal, this reflects in a reduction in total employment and output, making international interest rates counter-cyclical. Since employment durations are shorter in the informal sector, the international interest rate has less of a bite on informal employment, so the increase in international interest rates also reduces the proportion of formal workers and therefore increases the informality rate.

As a preliminary assessment of the presence of this mechanism in the data, we construct a measure of the real interest rate that Mexico faces in international markets using the EMBI spread as a proxy for the country-risk. We call this, in short, the international interest rate.[12] The first panel in Table 3 shows that, as it has been documented in several studies, the international interest rate is indeed counter-cyclical and volatile for Mexico and other emerging economies.[13]

[12] More precisely, we construct a series for the Mexican international interest rate using the 90-day T-bill rate plus the EMBI spread, minus the U.S. inflation (calculated using the GDP deflator).

[13] See, for instance, Neumeyer and Perri (2005) and Horvath (2018). We will use later the statistics from the first panel in Table 3 to calibrate the process for international interest rate shocks in the model.

More importantly, the second panel in Table 3 provides some evidence that international interest rates are inversely related to the contribution of job creation to total employment in the formal sector and positively related to its impact on the informality rate. In particular, if we compute the *counterfactual* employment rate as in the previous subsection, keeping all transition rates constant over time except for the gross flows from out to the labor force to formal employment, its correlation with the international interest rate for Mexico is negative, although not very large (-0.19). Notice that the effect dilutes when we add flows from out of the labor force to the informal sector, as in the last row of Table 3 (correlation becomes 0.01). Similarly, the *counterfactual* informality rate due to only flows from out of the labor force to formal employment is positively correlated to the international interest rate. Taking together, these findings are consistent with the key mechanism in the model that we describe in the next section.[14]

3 A Business Cycle Model with Labor Market Frictions and Self-Employment

We introduce a simple business cycle model for a small open economy, with aggregate technology and international interest rate shocks. The model features both formal and informal sectors, labor market frictions, and an endogenous participation in the labor force decision. The latter is necessary in order to account for the importance of cyclical movements in and out of the labor force. A representative family can choose to spend part of its time endowment working in the formal sector, working as self-employed in the informal sector, searching for formal jobs as unemployed or out of the labor force. The model captures in the formal sector the type of matching frictions in Merz (1995), Andolfatto (1996), and Boz et al. (2015), and includes as part of the institutional environment a payroll tax, rebated to consumers as a lump sum transfer, and a cost of destroying a work relationship modeled as a severance payment.

[14] We will abstract from the consequences for informality of the Labor Reform of 2012.

3.1 Production

There are three technologies in the economy. One to produce a final good, using intermediate inputs and capital. The intermediate goods are produced by formal workers or by self-employed, using linear production functions depending only on labor. We assume that the intermediate inputs produced in the formal and in the informal sector are imperfect substitutes. This structure allows us to derive a simple expression for the aggregate production function of the economy in which TFP has an endogenous component.

Final good production Intermediate inputs and capital are combined to produce a final good using a constant returns to scale technology:

$$Y_t = A_t \left(K_t\right)^{\alpha} \left(M_t\right)^{1-\alpha}, \tag{1}$$

where A_t is an aggregate technology shock in the final good sector following the stochastic process:

$$\log\left(A_t\right) = \rho_A \log\left(A_{t-1}\right) + \varepsilon_t^A,$$

in which ε_t^A is i.i.d. with mean zero and variance σ_A^2. We assume that the final good production is carried on by a representative firm under perfect competition. Hence, the rental price of capital and the price of the aggregate intermediate input satisfy the marginal conditions:

$$r_t = \alpha A_t \left(\frac{K_t}{M_t}\right)^{\alpha-1} \qquad p_t^M = (1-\alpha) A_t \left(\frac{K_t}{M_t}\right)^{\alpha}. \tag{2}$$

Intermediate goods production The aggregate intermediate good is a composite of inputs produced in the formal sector (M_t^f) and by self-employed workers (M_t^s), according to the CES aggregator,

$$M_t = \left\{ \left(M_t^f\right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(M_t^s\right)^{\frac{\varepsilon-1}{\varepsilon}} \right\}^{\frac{\varepsilon}{\varepsilon-1}} \tag{3}$$

with elasticity of substitution ε. We denote total formal employment as L_t^f and the mass of self-employed as L_t^s. Formal and self-employed workers produce their variety of intermediate

goods using linear deterministic technologies with productivities Ω and $\varkappa$. From the CES aggregator (3), we obtain the relative price of formal intermediate goods:

$$p_t^{M,f} = (1-\alpha) A_t \left(\frac{K_t}{M_t}\right)^{\alpha} \left(\frac{M_t}{\Omega L_t^f}\right)^{\frac{1}{\varepsilon}} \tag{4}$$

and the income of each self-employed worker

$$w_t^s = (1-\alpha)\, \varkappa A_t \left(\frac{K_t}{M_t}\right)^{\alpha} \left(\frac{M_t}{\varkappa L_t^s}\right)^{\frac{1}{\varepsilon}} = \varkappa p_t^{M,f} \left(\frac{M_t^f}{\varkappa L_t^s}\right)^{\frac{1}{\varepsilon}}. \tag{5}$$

Aggregation Combining (1) and (3), we obtain a simple aggregate production function for the economy:

$$\underbrace{Y_t}_{GDP} = \underbrace{\left[A_t \left\{ \left(\Omega\left(1-l_t^s\right)\right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(\varkappa l_t^s\right)^{\frac{\varepsilon-1}{\varepsilon}} \right\}^{\frac{\varepsilon(1-\alpha)}{\varepsilon-1}}\right]}_{TFP} \left(K_t\right)^{\alpha} \left(L_t\right)^{1-\alpha}, \tag{6}$$

where $L_t \equiv L_t^f + L_t^s$ denotes aggregate employment in both formal and informal sectors. The term in brackets represents measured TFP and includes both an exogenous (A_t) and an endogenous component, depending on the share of informal employment $l_t^s \equiv \frac{L_t^s}{L_t}$.

3.2 Matching and Labor Flows

Current unemployed workers U_t search for jobs; entrepreneurs post vacancies V_t. New formal matches are created through a standard, constant returns to scale, matching function combining both inputs according to $U_t^{\phi} V_t^{1-\phi}$.

Job finding and vacancy filling probabilities From the matching function specification, the probabilities p_t of a worker finding a match and q_t of a vacancy meeting a worker are given by:

$$p_t = \left(\frac{U_t}{V_t}\right)^{\phi-1} \qquad q_t = \left(\frac{U_t}{V_t}\right)^{\phi}. \tag{7}$$

Law of motion of formal employment At the beginning of the period, a mass L^f_{t-1} of workers are matched with a formal firm. An exogenous fraction s of formal workers are dismissed and become unemployed. New formal matches would become also active this period, so:

$$L^f_t = (1-s)\,L^f_{t-1} + q_t V_t. \tag{8}$$

3.3 Households and Workers

The consumer's side of the economy is modeled as representative family comprising a continuum of ex-ante identical workers. There is perfect risk-sharing among the members of the household, so each worker has the same level of consumption and the value of leisure is also equally allocated among workers.

Labor supply Households have a constant endowment of labor $\overline{L} = 1$ each period, which can be allocated in four occupational categories: Employed in the formal sector, self-employed, unemployed and out of the labor force.

$$\underbrace{L^f_t + L^s_t}_{employed} + \underbrace{U_t + O_t}_{non-employed} = 1.$$

Formal and self-employed workers pay the same utility cost in terms of leisure foregone, but generate labor income. Unemployed workers pay a search cost in utility terms, but if successful they can obtain a formal job in the current period, so that

$$L^f_t = (1-s)\,L^f_{t-1} + p_t U_t,$$

which is equivalent to the law of motion (8).

Preferences Household's preferences are described by the expected discounted lifetime utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[C_t - \varphi \frac{L_t^{1+\nu}}{1+\nu} - \frac{\varsigma}{2} U_t^2\right]^{1-\sigma}}{1-\sigma},$$

where C_t represents consumption and L_t denotes aggregate employment. This utility function is non-separable in consumption and leisure,[15] featuring a risk aversion coefficient $\sigma > 1$. The parameter φ governs the disutility of labor, ν is the inverse of the Frisch elasticity of labor supply, and ς controls the quadratic utility cost of search.

Savings and investment Households own the capital stock K_t and hold one-period, foreign bonds B_t. Investing I_t units of the final good increases the capital stock according to the law of motion:

$$K_{t+1} = (1-\delta) K_t + I_t - \frac{\vartheta}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 K_t.$$

Foreign bonds earn a return $r_t^* = (1 + i_t^*) \Theta(B_t)$, where i_t^* follows the stochastic process:

$$\log(1 + i_t^*) = \rho_i \log\left(1 + i_{t-1}^*\right) + (1-\rho_i) \log(1 + i^*) + \varepsilon_t^i,$$

in which disturbances ε_t^i are i.i.d. with mean zero and variance σ_i^2. We introduce $\Theta(B_t)$ as an endogenous risk premium with a small elasticity with respect to the net foreign asset position to ensure stationarity (see Schmitt-Grohé and Uribe, 2003).[16]

Budget constraint Each period, households face the budget constraint:

$$C_t + I_t + B_{t+1} = w_t L_t^f + w_t^s L_t^s + r_t K_t + (1 + r_t^*) B_t + \kappa s L_{t-1}^f + \Pi_t + T_t,$$

where κ is the separation cost (severance payment) received by dismissed workers, Π_t denotes the profits made by entrepreneurs and T_t is a lump sum transfer by the government.

[15] This utility function, also known as GHH, has been used extensively in small open economy models to mitigate the impact of wealth effects on labor supply.

[16] Our model does not feature the possibility of investing in a domestic financial asset.

Optimization Given initial conditions B_0, K_0, L^f_{-1}, sequences for contingent prices w_t, w^s_t, r_t, job finding rates p_t, profits Π_t, transfers T_t, and the stochastic process for aggregate shocks, the representative household chooses contingent plans for aggregate variables $C_t, I_t, , K_{t+1}, B_{t+1}, L^f_t, L^s_t$, U_t, O_t in order to maximize utility subject to the budget constraint, the time allocation constraint, and the laws of motion for labor and capital.

3.4 Wage Determination

To close the model, we need to specify how formal wages are determined in this economy. As is standard in the literature, we assume that wages are determined by repeated bargaining between the entrepreneur and the worker using the Nash protocol. Our wage setting mechanism precludes a bonding scheme to undo the distortion introduced by the severance payment.

Value of a formal worker We denote λ^L_t the utility value for the household of having an employed worker in the formal sector. We define this value recursively as:

$$\lambda^L_t \equiv \left(w_t - \varphi\left(L^f_t + L^s_t\right)^{\nu}\right) U_{c,t} + \beta E_t\left[(1-s)\,\lambda^L_{t+1} + s\kappa U_{c,t+1}\right], \tag{9}$$

where $U_{c,t}$ is the marginal utility of consumption.[17] Similarly, we can define recursively the value of a match for the entrepreneur as:

$$J_t \equiv \left(p^{M,f}_t \Omega - (1+\tau)\, w_t\right) U_{c,t} + \beta E_t\left[(1-s)\, J_{t+1} - s\kappa U_{c,t+1}\right]. \tag{10}$$

where $\tau$is a payroll tax collected by the government.

Nash-bargaining Every period, after observing the shocks, the formal wage w_t solves:

$$w_t = \arg\max\left\{\left(\lambda^L_t\right)^{\gamma}\left(J_t + \kappa U_{c,t}\right)^{1-\gamma}\right\},$$

[17] Under this definition, λ^L_t corresponds to the optimal value of the Lagrange multiplier for the law of motion for formal employment, according to the first order conditions for household's optimization. See Appendix B for details.

where γ is the weight assigned to the worker. The value function J_t, as defined in (10), captures the value for an entrepreneur of keeping a match. The entrepreneur's outside option is closing the match at a utility cost $\kappa U_{c,t}$. On the other hand, λ_t^L, as defined in (9), represents the net value for the household of keeping a worker in the formal sector. From this problem we obtain the standard sharing rule:

$$(1-\gamma)\,\lambda_t^L = \gamma(J_t + \kappa U_{c,t})\,. \tag{11}$$

Zero-profit condition for vacancy posting Formal entrepreneurs can post vacancies at a cost η. A vacancy only lasts for a period. If the vacancy meets a worker, with probability q_t, the match becomes active in the current period. Assuming competitive entrepreneurs, the zero-profit condition for vacancy posting implies:

$$q_t J_t = \eta U_{c,t}. \tag{12}$$

3.5 Equilibrium

An equilibrium with Nash-bargaining for this economy is a set of contingent plans for aggregate quantities and prices such that:

1. Consumers solve their optimization problem;

2. Input prices satisfy the marginal conditions in (2), (4) and (5) and the aggregate production function (6) holds;

3. Labor flows follow the law of motion (8), and meeting probabilities are given by (7);

4. The Nash sharing rule (11) determines the wage schedule, with values for entrepreneur and the formal worker given by (10) and (9), respectively, and vacancy posting satisfies the zero-profit condition (12); and

5. Markets clear and government balances budget

$$Y_t = C_t + I_t + \eta V_t + NX_t,$$

$$B_{t+1} = (1 + r_t^*) B_t - NX_t,$$

$$\Pi_t = p_t^{M,f} M_t^f - (1 + \tau) w_t L_t^f - \kappa s L_{t-1}^f,$$

$$T_t = \tau w_t L_t^f.$$

The complete system of equations characterizing the equilibrium is presented in Appendix B, together with a description of the solution method.

4 Quantitative Results

We calibrate the model to aggregate data for Mexico in the period 2005-2016. The time period is dictated by the availability of data for labor flows and occupational status, which we take from the ENOE survey. The model does a good job replicating some statistics not used in the calibration process, as the correlations between GDP and the employment and the informality rates. For this, it is key the presence of international interest rate shocks, which affect disproportionally job creation in the formal sector. In contrast to the previous literature, our mechanism does not rely on the output of the informal sector being imperfectly measured.

4.1 Calibration

Table 4 summarizes the calibration results. Each period is equivalent to one quarter. We assume a standard risk aversion coefficient of 2. The discount factor β implies an annual real interest rate of 4 percent and the depreciation rate δ is set to 5 percent per year. We choose an elasticity θ of 0.4, consistent with the work of Blanchard and Diamond (1990). The exogenous separation rate s corresponds to a quarterly exit rate from the formal sector

Parameter	Symbol	Value
Risk aversion coefficient	σ	2
Discount Factor	β	0.99
Depreciation Rate	δ	1.25%
Elasticity of Matching Function	θ	0.40
Payroll Tax	τ	0.25
Separation Rate	s	8.8%
Persistence - AR(1) Productivity Shock	ρ_A	0.92
Disutility of Labor	φ	1.49
Productivity Informal Sector	$\varkappa$	0.72
Search Cost	ς	82.1
Productivity Formal Sector	Ω	1.13
Workers' Bargaining Power	γ	0.67
Capital Share in Production Function	α	0.23
Firing Cost	κ	1.40
S.D. Innovations - AR(1) International Interest Rate	σ_i	0.41%
Persistence - AR(1) International Interest Rate	ρ_i	0.92
S.D. Innovations - AR(1) Productivity Shock	σ_A	0.50%
Frisch Elasticity of Labor Supply	$1/\nu$	3.2
Elasticity of Substitution Formal - Informal Inputs	ε	7.65
Cost of posting a vacancy	η	0.03
Adjustment Cost of Capital	ϑ	46.5

Table 4: Parameters for the Baseline Economy

of 8.8 percent.[18] We also set the payroll tax τ to 0.25, consistent with the estimates in Leal (2014) and Alonso-Ortiz and Leal (2017), and a persistence ρ_A of the exogenous technology shock equal to the observed persistence of GDP (see first row of Table 2).

The disutility of labor parameter φ, the productivity of the informal sector χ, the search cost ς, the productivity of the informal sector Ω, the worker's bargaining power γ, the capital share in the production function α, and the size of the firing cost κ, are jointly calibrated to reproduce the following seven targets for Mexico in steady state:

[18] We compute this quarterly exit rate from the ENOE survey as the sum of the transition rate from formal employment to non-employment (unemployment or out of the labor force) and the *net* transition rate from formal to informal employment, averaged over the whole 2005-2016 period. Since the model does not feature a direct transition from informal to formal employment (only unemployed workers can search for formal jobs) we use the *net* transition from formal to informal employment instead of the *gross* transition between these two states. The latter implies a much larger exit rate from the formal sector, of about 19%. The results of the quantitative exercises under an alternative calibration with an exit rate of 19% (available upon request) do not change our message.

1. A total employment rate as a fraction of the working-age population of 55.7%;[19]

2. An informality rate (over total employment) of 55.9%;

3. An unemployment rate (over total employment) of 4.75%;

4. An endogenous aggregate TFP for the economy normalized to one;

5. A wage premium in the formal sector (relative to the informal sector) of 13%;[20]

6. A capital share in total income of $1/3$;

7. A separation cost equivalent to 13 weeks of the average wage.[21]

We then estimate the $AR(1)$ process for the interest rate that Mexico faces in international markets, as described in Section 2. Finally, we jointly calibrate the standard deviation σ_A of the technology shock, the curvature of leisure in the utility function ν, the elasticity of substitution between formal and informal inputs ε, the cost of a vacancy η, and the adjustment cost of capital ϑ to match the observed volatilities of GDP, the employment rate, the informality rate and aggregate investment, and the correlation between the international interest rate and GDP.[22]

From this last set of parameters, notice that we obtain an elasticity of labor supply in the order of 3, which is twice the value used in Neumeyer and Perri (2005), Lama and Urrutia (2011), and other models of business cycles in emerging markets. None of these models,

[19] This number and the next two targets correspond to our own calculations using the ENOE survey, as discussed in the empirical section.

[20] This premium corresponds to the value obtained for Mexico by Alcaraz et al. (2011), using the old ENEU survey for the period 2001-2004 and correcting for the economic activity of the worker.

[21] We use the study by Heckman and Pagés-Serra (2000) to obtain a comprehensive measure of employment protection for Mexico as a target for calibrating the separation cost κ. These authors compute all the legal costs and obligations for a firm firing a worker, adding to an equivalent to 13 weeks of wages.

[22] The time series for GDP, consumption and investment are obtained from INEGI, the national statistics agency. Consumption is total consumption, including that of the government. Similarly, investment corresponds to the sum of private and public capital formation. The series for the international interest rate and the labor market variables are our own construction using the EMBI spread and the ENOE survey, as discussed in Section 2. All series correspond to the period 2005-2016, are seasonally adjusted and detrended using the HP-filter (with smoothing parameter 1600). The corresponding time series simulated from the model are also HP-filtered.

	Data Mexico	Baseline Model	No r^* Shocks	Unmeasured Informal M^s
$\sigma(Y)$	1.57	1.57	1.50	1.60
$\sigma(C)/\sigma(Y)$	1.11	1.29	0.98	1.19
$\sigma(I)/\sigma(Y)$	1.98	1.98	1.25	1.86
$\sigma(L)/\sigma(Y)$	0.42	0.42	0.43	0.41
$\sigma(l^s)/\sigma(Y)$	0.53	0.53	0.14	0.51
$\sigma(1+i_t^*)$	0.52	0.52	–	0.52
$Corr(L,Y)$	0.76	0.98	0.99	0.97
$Corr(L^s,Y)$	0.06	0.46	0.95	0.39
$Corr(l^s,Y)$	−0.56	−0.26	0.18	−0.33
$Corr(O+U,Y)$	−0.77	−0.98	−0.99	−0.97
$Corr(U,Y)$	−0.91	0.39	0.71	0.41
$Corr(1+i^*,Y)$	−0.30	−0.30	–	−0.41

Table 5: Business Cycle Statistics: Data and Model

though, features an informal sector. The elasticity of substitution between formal and informal inputs is close to 8, the benchmark value used in Restrepo-Echavarria (2014) and Fernández and Meza (2015). Finally, the implied vacancy cost is very small, about 6 percent of the monthly formal wage.

4.2 Business Cycle Properties

Table 5 reports several business cycle statistics for the Mexican economy and computed from data simulated from the model. The baseline model is calibrated to match the volatilities of GDP, investment, total employment, the informality rate, and the international interest rate. Notice that the model reproduces the pro-cyclicality of total employment and the counter-cyclicality of the informality rate and the non-employment state. Moreover, the counter-cyclicality of the informality rate is generated in the model, as in the data, by movements in formal employment, since informal employment (as a percentage of the working-age population) is mildly pro-cyclical. These properties of informal employment along the business cycle were not explicit targets in the calibration exercise.

The main discrepancy between the model and the data is the cyclical behavior of the un-

employment rate.[23] In the data, unemployment is highly counter-cyclical, while in the model it is mildly pro-cyclical.[24] This is because our setup includes and endogenous participation decision, giving unemployment the interpretation of job search effort by households (notice how it appears in the utility function), instead of just the residual of employment. Recessions are the worst moments to pay for the cost of this effort, since the payoff is relatively low due to smaller job-finding probabilities and lower wages. Hence households in our model search for jobs in periods of expansion, making unemployment pro-cyclical.[25]

A pro-cyclical unemployment rate in our model is clearly at odds with the data. However, its alternative interpretation as job search intensity may find some support in the literature. In the U.S., for instance, there is no consensus about the intensity at which the unemployed search for jobs along the business cycle. A counter-cyclical job search has been advocated by Shimer (2004), Mukoyama et al. (2018), and Leyva (2018) but contested by DeLoach and Kurt (2013) and Gomme and Lkhagvasuren (2015).

Finally, it is remarkable that the model generates a counter-cyclical international interest rate, and in a comparable magnitude to the data, even though the stochastic processes for technology and interest rates are independent. We explain next the mechanism behind this and the previous results.

The role of technology and international interest rate shocks

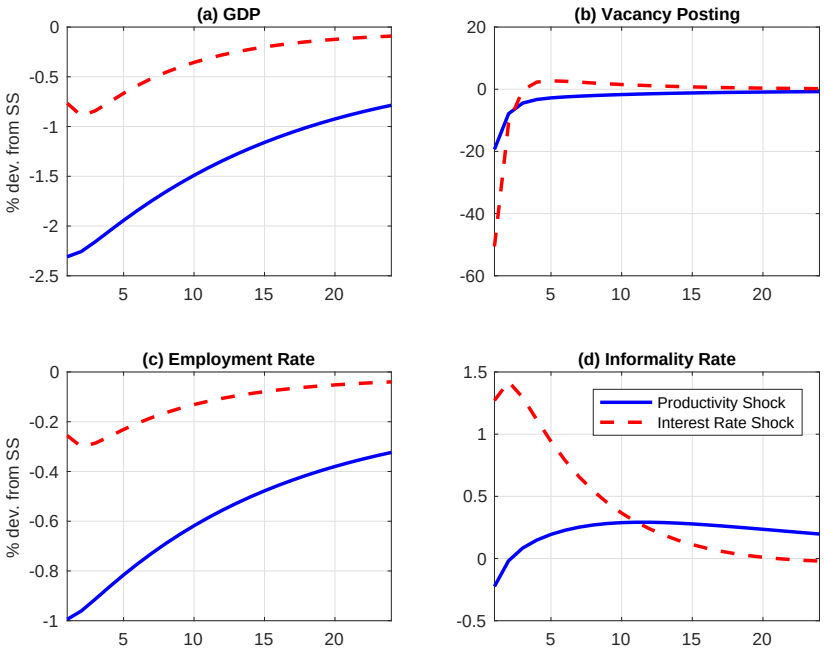
To understand the sources of these results, Figure 4 plots the impulse response functions of the model to a 1% negative technology shock (solid line) and a 1% *positive* international interest rate shock. The negative technology shock reduces the demand for intermediate goods,

[23] In the model and in Table 5 the variable U denotes the unemployment rate as a percentage of population, instead of as a percentage of active population (net of inactivity) as in Table 2. Hence the small differences between the "data" statistics for this variable in the two tables, even though they are computed using the same ENOE survey.

[24] Notice, though, that unemployment in our calibrated model is small, so it does not affect the dynamics of non-employment ($U + O$) which is driven mostly by changes in participation rates. In that sense, the model replicates well the counter-cyclicality of non-employment.

[25] Krusell et al. (2017) present a model with endogenous participation that is able to generate a counter-cyclical unemployment rate. For this, they introduce heterogeneous households that are unable to insure among themselves against unemployment spells. This is an important extension which is, however, outside the scope of our paper.

Figure 4: Impulse Response Functions to a Negative Technology Shock and to a Positive Interest Rate Shock



and then the demand for labor in both sectors. In contrast to Fernández and Meza (2015), we do not assume a different technology shock for formal and informal sectors, which would give us enough degrees of freedom to account mechanically for the behavior of the informality rate. Therefore, the (symmetric) negative technology shock reduces total employment and GDP, but has almost no impact on the informality rate. In the context of our model an alternative economy with only technology shocks would experience smaller and less cyclical fluctuations in the informality rate, as shown in the third column of Table 5.

A positive international interest rate shock also has a contractionary effect through job creation in the formal sector. The mechanism, which is key in our analysis and novel to the literature on the dynamics of informality, is the following. An increase in international interest rates reduces the present value of a job for an entrepreneur in a long term labor relationship, by increasing the rate at which future payoffs are discounted, and disincentivizes vacancy posting. In that sense, an increase in international interest rates acts as a negative technology shock, affecting disproportionally sectors with less labor flexibility and longer

employment durations. In our setup, as in the data, formal employment is less flexible and exhibits longer durations than informal, modeled for simplicity as a static self-employment decision.[26]

One implication of the mechanism is that the international interest rate is counter-cyclical, as observed in the data. Moreover, while a negative technology shock has a small negative impact on the informality rate, a positive international interest rate shock increases it by reducing the share of formal workers in the economy. The interaction between the two shocks allows us to account for a counter-cyclical informality rate driven by the cyclicality of formal employment, instead of fluctuations in informal employment.[27]

4.3 Unmeasured Informal Output

We are assuming in our analysis that all output is measured correctly as captured in the "official" GDP measure. This is a strong assumption which seems contrary to the view of the informal sector as part of a shadow economy beyond the scope of government statistics. However, even though informal production is undetected for taxation purposes, statistical agencies make an important effort to estimate the size of the informal sector (using household and labor surveys, combined with the currency demand approach, and so on) and include it in their GDP measure.[28] Estimates of informal output are certainly less than perfect, but we believe that the assumption of perfect measurement is a better approximation than the other extreme assumption (made in Restrepo-Echavarria (2014) and Fernández and Meza (2015),

[26] In our baseline calibration, the quarterly exit rate of 8.8% in the formal sector implies an average duration of the formal employment status of 2.8 years. The comparable exit rate from informal employment (obtained as the sum of the transitions from informal employment to non-employment in our ENOE sample) is much larger, 17.2%, implying an average duration of 1.5 years for informal employment. Adding the transitions from informal to formal employment to the previous exit rate would imply an even smaller duration of just less than one year.

[27] In a recent paper, Horvath (2018) explores a related mechanism in which competitive firms face a working capital constraint to the purchase of labor services, à la Neumeyer and Perri (2005). The asymmetry comes from the assumption that only firms in the formal sector have access to credit and face this constraint, while informal firms do not use working capital. The results are hard to compare to ours since the author focuses on the volatility of consumption and net exports and does not report the implications for the informality rate.

[28] For instance, the GDP measure by the statistical office in Mexico includes an estimate of the informal sector output, which accounts for about 25% of total GDP. This share varies over time and over the business cycle, in a stable range from 23% to 27%. See INEGI (2015) for a detailed description of the methods use to estimate the value added produced by the informal sector.

among others) in which GDP only includes the output produced in the formal sector.

Still, we can consider an intermediate case in which a fraction of the informal sector output (M^s in our model) is not included in GDP. Of course, that fraction would be extremely arbitrary, but for illustrative purposes let's make it one-third. The last column in Table 5 reports the results for this alternative version of the model. Now, reallocating workers between the two sector generates mechanically larger swings in measured productivity. The results are, however, quantitatively similar. If anything, the fit of the model improves in two dimensions: the informality rate becomes more counter-cyclical, and informal employment less pro-cyclical.

In that sense, our results are robust to assuming some unmeasured informal output. But more importantly, in contrast to the other papers mentioned above, we do not rely on this assumption to generate empirically reasonable fluctuations in output and employment.

5 Informality, Labor Regulation, and the Business Cycle

We interpret the informal sector in Mexico as a response of the economy to restrictive regulation, in particular to labor relations, in an environment in which enforcement of this regulation is weak. As discussed in the introduction, Mexico and other emerging economies feature high degrees of employment protection, incorporated in our analysis as firing costs. In this final section we ask two related questions in the context of the model: Given the labor regulation, to which extent the informal sector makes the labor market more "flexible" along the business cycle? And, what are the effects on the informal sector and the business cycle of reducing the degree of employment protection?

5.1 The Informal Sector and the Business Cycle

We first discuss the effect of informality (or, more concretely, of low enforcement) on the business cycle in an economy characterized by high employment protection. For this, we

compare our baseline economy with an alternative economy without the informal sector.[29] To make the results comparable, the alternative economy is calibrated to match the same steady-state targets as the baseline, with the exception of course of the informality rate which is assumed to be zero. The first two columns in Table 6 compare the business cycle properties of the two economies.

Confronted with similar shocks, the economy without an informal sector features higher employment and consumption volatility. The option of the informal sector provides more flexibility to households to accommodate shocks, helping to smooth the impact of business cycles on the labor market. Notice however that there is a cost. Given the lower productivity of the informal sector (which is reflecting the existence of a formal wage premium in the data), the volatility of measured TFP increases in the economy with the informality option. In other words, informality amplifies the impact of technology shocks on measured TFP and output.

This amplification effect was shown by Fernández and Meza (2015) in a model in which total employment is fixed, so TFP volatility mechanically translates into GDP volatility. We obtain a similar result adding the endogenous participation margin and derive a novel prediction on consumption volatility. Notice again that the experiment refers to eliminate exogenously the informality option without removing one of its deepest causes, which is the burden of labor regulation. We turn next to the impact of reducing the size of the informal sector by softening this burden.

5.2 Reducing the Burden of Labor Regulation

Now, we analyze the second question. Taken as given the existence of an informality option (due perhaps to low enforcement), what is the impact of a labor reform that reduces the degree of employment protection or the tax burden for the formal sector? Starting from the baseline model, the last two columns in Table 6 reports the results of the experiment of lowering the

[29] This alternative model assumes that perfect monitoring from the government eliminates self-employment as an option for workers. It can be nested into our original model by setting the productivity of the informal sector χ to zero.

	Baseline	No Informality	Low Firing Costs	Low Payroll Tax
Steady State Levels:				
Employment Rate (L)	55.7%	55.7%	66.8%	69.6%
Informality Rate (l^s)	55.9%	–	38.7%	35.5%
TFP	100	100	105.1	105.7
Business Cycle Properties:				
$\sigma(Y)$	1.57	1.53	1.52	1.54
$\sigma(C)/\sigma(Y)$	1.29	1.39	1.03	1.35
$\sigma(L)/\sigma(Y)$	0.42	0.49	0.52	0.54
$\sigma(l^s)/\sigma(Y)$	0.53	–	0.35	0.49
$\sigma(TFP)$	0.67	0.63	0.62	0.63
$Corr(L^s,Y)$	0.46	–	0.61	0.34
$Corr(l^s,Y)$	−0.26	–	−0.10	−0.22

Table 6: Effects of Reducing Informality in the Model

firing cost κ or the payroll tax τ to half their initial value.

As expected, the long run impact of the reform is to increase total employment and reduce the fraction of informal workers. This is because, given an exogenous separation rate, lower firing costs increase the value of a match for entrepreneurs and incentivize vacancy posting. Since the formal sector is by construction more productive, the economy with a less burdensome labor regulation also features between a 5% and 6% higher TFP level in steady state. This number gives us a measure of the extent of misallocation in the model induced by employment protection and payroll taxes.[30]

Confronted with similar shocks, the economy with lower formality costs exhibits higher employment volatility. The value of a match becomes more sensitive to business cycle conditions and therefore hirings are more pro-cyclical. However, reducing firing costs or payroll taxes attenuate the volatility of measured TFP because of a lower incidence of the (unproductive) informality margin adjustment. In our calibrated model, the TFP effect is large enough so that it reduces GDP volatility, even though it increases the fluctuations in employment.[31]

[30] Of course, one has to be careful not to read too much into this number, since we are abstracting from decreasing returns in the formal sector, heterogeneity in workers' skills and self-selection into occupational categories. All these features could reduce the efficiency gains of reducing employment protection.

[31] These results mimic the findings in Lama and Urrutia (2011), in which firing costs amplify the impact of macroeconomic shocks on measured TFP and output. The mechanism is different, though. Lama and Urrutia (2011) study an economy with no informal sector, but with a selection effect coming out of an endogenous

These experiments may shed some light on the differences between emerging and developed economies reported in Table 1 in the introduction. Even if everything else were equal, which is certainly not the case, economies with higher burden of labor regulation and low enforcement would feature: (i) more output volatility; (ii) less total employment volatility relative to output; and (iii) a larger informal sector. Moreover, in our model such economies would also exhibit a negative correlation between international interest rates and output and higher consumption volatility, two additional features that distinguish emerging and developed economies (see Neumeyer and Perri, 2005 and Horvath, 2018).

6 Conclusions

Some important characteristics of the Mexican labor market are: (i) inflexible formal employment, with a high burden of labor regulation, (ii) low enforcement reflected in the high incidence of informal employment, and (iii) frequent movements in and out of the labor force. These features, shared by labor markets in several emerging economies, shape the response of employment to macroeconomic shocks and thereby affect the business cycle.

We propose a business cycle model for a small open economy in which the interaction between labor market frictions and the decision of workers to employ in the informal sector plays a key role. The model features a novel mechanism: international interest rate (risk premium) shocks affect the allocation of workers between the formal and informal sector via its impact on formal job creation. We show that both technology and international interest rate shocks are needed to reproduce the business cycles properties of the Mexican economy, in particular the correlation between the informality rate and aggregate output and the countercyclicality of international interest rates.

The presence of an informal sector might help to mitigate the impact of a stringent labor regulation on employment and consumption fluctuations. In that sense, it adds flexibility to the economy in its adjustment to shocks. In our model, however, the cost is a lower

separation decision with jobs subject to idiosyncratic match quality shocks, as in Mortensen and Pissarides (1994).

productivity and an excess TFP and output volatility. Reducing the burden of labor regulation to the formal sector might achieve the goal of reducing output volatility while improving at the same time the efficiency in the allocation of resources. Further analysis is required, though, to provide an assessment of the welfare effects of labor regulation in a more realistic environment with heterogeneous workers and imperfect risk-sharing.

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Appendix

A Composition Changes in the Informality Rate

In this appendix we investigate whether the cyclical properties of the informality rate reported in the paper are driven by changes in the distribution of the employed population across selected variables. One might think, for instance, that recessions are particularly disruptive for certain groups depending on their education level, age, sex, and the economic activity to which they belong.

The informal employment rate L^s could be decomposed as follows:

$$\underbrace{\frac{\text{informal employment}}{\text{population}}}_{\text{informal employment rate, } L^s} = \underbrace{\frac{\text{informal employment}}{\text{total employment}}}_{\text{informality rate, } l^s} \times \underbrace{\frac{\text{total employment}}{\text{population}}}_{\text{employment rate, } L}.$$

In principle, composition changes may affect the dynamics of the three employment rates. It is important, however, to distinguish the nature of those changes in the decomposition above. Thus, composition changes in both L^s and L will be due to changes in the population weights, which will rarely vary at business cycle frequencies. By contrast, varying employment weights are at the core of composition changes in l^s.

The observed informality rate could be written as follows, with t denoting the time index:

$$l_t^s = \sum_i l_{it}^s \, \mu_{it}^s,$$

where the index i denotes a specific, say, education group and μ_i denotes its share in overall employment. We call this rate the "naive" informality rate because it confounds "real" changes and purely composition changes that say little or nothing about real propensities to be an informal worker. We construct counterfactual rates by holding the employment weights

fixed at their average values in the sample period $\bar{\mu}_i$:

$$\tilde{l}_t^s = \sum_i l_{it}^s \, \bar{\mu}_i^s.$$

In panel A of Figure 5 we plot l^s and $\tilde{l}^s$ for all our selected variables. We highlight the striking bias that changes in the distribution of working people over years of schooling are producing in the observed informality rate. For the rest of the variables the role of these changes are rather negligible.

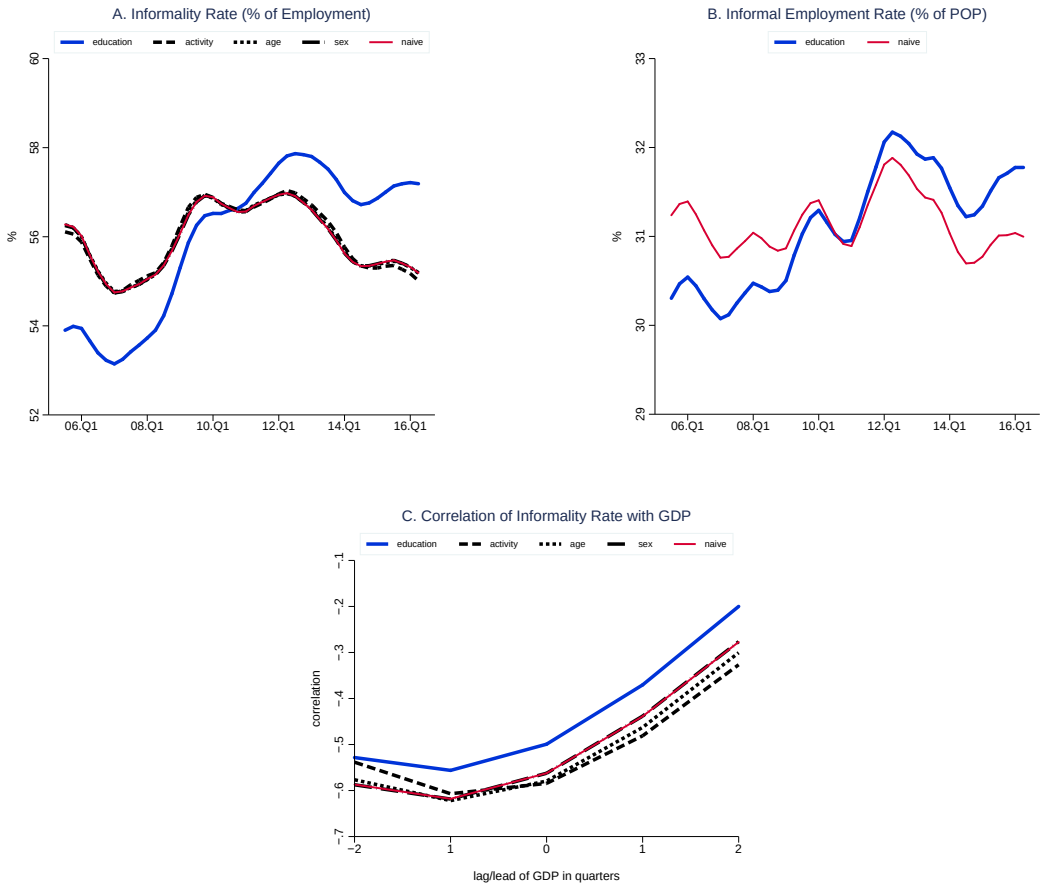
Two caveats are in order. First, although the bias induced by education is patently important, the major implication of these changes seems to be on the trend of the informality rate and not on its cyclical shape. Notice that both the surge in the share of informal workers during the Great Recession of 2008-2009 and its subsequent fall around 2012 is shared by both the naive measure and this counterfactual rate.

Lending support to the first caveat, the second one is that changes in the employment shares may well be a reflection of changes in the population weights, which are instead associated with demographic rather than cyclical movements.[32] To shed light on this issue, we construct a counterfactual measure of the informal employment rate $\tilde{L}^s$ by holding the *population* weights constant throughout the sample period. We plot this rate along with the naive rate L^s in panel B of Figure 5. It is revealing that the smoothing out of the informal employment (as a percentage of population) attributed to changes in the population weights mimics that of the informality rate once the employment shares are allowed to vary.

To be concrete we report the correlation of all the series displayed in panel A with GDP, its lags and leads, in a way of mimicking the information displayed in the tables reported in the main text (see panel C). All the correlations calculated for the informality rate that controls for bias stemming from education are slightly weaker than the rest. The contemporaneous correlation is 0.50 while the counterpart coefficient calculated with the naive rate is 0.56. We conclude that the role played by composition changes in the dynamics of the informality rate has been rather minor at best, at least at business cycle frequencies.

[32] The demographic effect of education on informality has also been documented by Levy and Székely (2016).

Figure 5: Composition Changes in the Informality Rate



Notes: Panel A shows estimates of quarter fixed effects from a regression of informality rate as percentage of employment with no other controls. Regressions are estimated on weighted data. "Naive" corresponds to the raw time series. The rest of the series correspond to counterfactual rates, which deliver the informality rate one would observe had the employment weights (over say age) remained equal to their sample averages in the period. Counterfactual rates are calculated using the equation in the text of this appendix. Education, economic activity, and age are grouped in bins. Education (years of schooling): 1-3, 4-6, 7-9, 10-12, and 13 and more. Economic activity (North American Industry Classification System): (1) agriculture, forestry, fishing, and hunting, (2) mining and utilities, (3) manufacturing, (4) construction, (5) wholesale and retail trade, (6) food services and accommodation, (7) transportation, warehousing, and information, (8) professional and business services, (9) social services (education, health, and social assistance), (10) arts, entertainment, recreation, and other services (except government), and (11) government. Age: 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75 and over. All quarterly series were constructed using the ENOE survey and smoothed out using the centered to moving average to clean up for seasonality. Non-earner workers are excluded from the sample. Panel B shows estimates of quarter fixed effects from a regression of informal employment to population (POP) ratio with no other controls. Regressions are estimated on weighted data. 'Naive' corresponds to the raw time series. "Education" is the counterfactual rate that delivers the informal employment rate one would observe had the *population* weights over years of schooling remained equal to its sample average in the period. This rate is calculated using the equation in the text of this appendix but with population weights instead. Panel C shows how the business cycle properties of the informality rate change when correcting for composition changes attributed to education, economic activity, age, and sex. "Naive" corresponds to the business cycle properties of the informality rate reported in Table 2 in the main text.

B Solving the Equilibrium

B.1 Consumer's First Order Conditions

Given initial conditions B_0, K_0, L^f_{-1}, prices w_t, w^s_t, r_t, job finding rates p_t, profits Π_t, and the stochastic process for aggregate shocks, the representative household chooses contingent plans for aggregate variables $\left\{C_t, I_t, , K_{t+1}, B_{t+1}, L^f_t, L^s_t, U_t, O_t\right\}_{t=0}^{\infty}$ in order to solve

$$\max \quad E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[C_t - \varphi \frac{\left(L^f_t + L^s_t\right)^{1+\nu}}{1+\nu} - \frac{\varsigma}{2} U_t^2\right]^{1-\sigma}}{1-\sigma},$$

$$\text{s.to.} \qquad C_t + I_t + B_{t+1} = w_t L^f_t + w^s_t L^s_t + r_t K_t + (1 + r^*_t) B_t + s\kappa L^f_{t-1} + \Pi_t + T_t, \qquad (\beta^t \lambda^C_t)$$

$$K_{t+1} = (1-\delta) K_t + I_t - \frac{\vartheta}{2} \left(\frac{I_t}{K_t} - \delta\right)^2 K_t, \qquad (\beta^t \lambda^K_t)$$

$$L^f_t = (1-s) L^f_{t-1} + p_t U_t, \qquad (\beta^t \lambda^L_t)$$

$$L^f_t + L^s_t + O_t + U_t = \overline{L}, \qquad (\beta^t \lambda^O_t)$$

(the stationary Lagrange multipliers are in parenthesis) with first order conditions:

$$
\begin{aligned}
\frac{\partial}{\partial C_t} \quad &: \quad \lambda_t^C = \left[C_t - \varphi \frac{\left(L_t^f + L_t^s \right)^{1+\nu}}{1+\nu} - \frac{\varsigma}{2} U_t^2 \right]^{-\sigma} \equiv U_{c,t}, \\
\frac{\partial}{\partial I_t} \quad &: \quad \lambda_t^C = \lambda_t^K \left(1 - \vartheta \left(\frac{I_t}{K_t} - \delta \right) \right), \\
\frac{\partial}{\partial K_{t+1}} \quad &: \quad \lambda_t^K = \beta E_t \left\{ \lambda_{t+1}^C r_{t+1} + \lambda_{t+1}^K \left(1 - \delta + \vartheta \left(\frac{I_{t+1}}{K_{t+1}} - \delta \right) \frac{I_{t+1}}{K_{t+1}} - \frac{\vartheta}{2} \left(\frac{I_{t+1}}{K_{t+1}} - \delta \right)^2 \right) \right\} \\
\frac{\partial}{\partial B_{t+1}} \quad &: \quad \lambda_t^C = \beta E_t \lambda_{t+1}^C \left(1 + r_{t+1}^* \right), \\
\frac{\partial}{\partial L_t^f} \quad &: \quad \lambda_t^L = w_t \lambda_t^C - U_{c,t} \varphi \left(L_t^f + L_t^s \right)^{\nu} - \lambda_t^O + E_t \left[(1-s) \lambda_{t+1}^L + s \kappa \lambda_{t+1}^C \right], \\
\frac{\partial}{\partial O_t} \quad &: \quad \lambda_t^O = 0, \\
\frac{\partial}{\partial L_t^s} \quad &: \quad w_t^s \lambda_t^C = U_{c,t} \varphi \left(L_t^f + L_t^s \right)^{\nu} + \lambda_t^O, \\
\frac{\partial}{\partial U_t} \quad &: \quad p_t \lambda_t^L = U_{c,t} \varsigma U_t + \lambda_t^O.
\end{aligned}
$$

From the last five first order conditions, using $\lambda_t^C = U_{c,t}$, we obtain a condition characterizing the optimal level of unemployment (and search) for the household,

$$p_t \lambda_t^L = \varsigma \lambda_t^C U_t,$$

another for the optimal supply of self-employed labor

$$w_t^s = \varphi \left(L_t^f + L_t^s \right)^{\nu}$$

and a recursive expression for the marginal value of a formal worker for the household

$$\lambda_t^L = \left[w_t - \varphi \left(L_t^f + L_t^s \right)^{\nu} \right] \lambda_t^C + \beta E_t \left[(1-s) \lambda_{t+1}^L + s \kappa \lambda_{t+1}^C \right].$$

B.2 Summarizing

The equilibrium is characterized by the following system of equations in the following 19 sequences: λ_t^C, λ_t^L, Y_t, C_t, I_t, M_t, K_{t+1}, L_t^f, L_t^s, U_t, O_t, V_t, J_t, B_{t+1}, w_t, $p_t^{M,f}$, w_t^s, p_t, q_t:

1. $\lambda_t^C = \left[C_t - \varphi \frac{\left(L_t^f + L_t^s\right)^{1+\nu}}{1+\nu} - \frac{\varsigma}{2} U_t^2 \right]^{-\sigma}$
2. $\lambda_t^C = \beta E_t \lambda_{t+1}^C \left(1 + r_{t+1}^*\right)$
3. $\lambda_t^C = \left(1 - \vartheta\left(\frac{I_t}{K_t} - \delta\right)\right) \beta E_t \left\{ \lambda_{t+1}^C \left[\alpha A_t \left(\frac{K_{t+1}}{M_{t+1}}\right)^{\alpha-1} + \left(\frac{1 - \delta + \vartheta\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\frac{I_{t+1}}{K_{t+1}} - \frac{\vartheta}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)^2}{\left(1 - \vartheta\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\right)} \right) \right] \right\}$
4. $\varsigma \lambda_t^C U_t = p_t \lambda_t^L$
5. $w_t^s = \varphi \left(L_t^f + L_t^s\right)^{\nu}$
6. $\lambda_t^L = \left[w_t - \varphi \left(L_t^f + L_t^s\right)^{\nu} \right] \lambda_t^C + \beta E_t \left[(1-s) \lambda_{t+1}^L + s \kappa \lambda_{t+1}^C \right]$
7. $L_t^f + L_t^s + U_t + O_t = \overline{L}$
8. $K_{t+1} = (1-\delta) K_t + I_t - \frac{\vartheta}{2} \left(\frac{I_t}{K_t} - \delta\right)^2 K_t$
9. $Y_t = A_t \left(K_t\right)^{\alpha} \left(M_t\right)^{1-\alpha}$
10. $M_t = \left\{ \left(\Omega L_t^f\right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(\varkappa L_t^s\right)^{\frac{\varepsilon-1}{\varepsilon}} \right\}^{\frac{\varepsilon}{\varepsilon-1}}$
11. $p_t^{M,f} = (1-\alpha) A_t \left(\frac{K_t}{M_t}\right)^{\alpha} \left(\frac{M_t}{\Omega L_t^f}\right)^{\frac{1}{\varepsilon}}$
12. $w_t^s = \varkappa p_t^{M,f} \left(\frac{\Omega L_t^f}{\varkappa L_t^s}\right)^{\frac{1}{\varepsilon}}$
13. $J_t = \left(p_t^{M,f} \Omega - (1+\tau) w_t \right) \lambda_t^C + \beta E_t \left[(1-s) J_{t+1} - s \kappa \lambda_{t+1}^C \right]$
14. $q_t J_t = \eta \lambda_t^C$
15. $(1-\gamma) \lambda_t^L = \gamma \left(J_t + \kappa \lambda_t^C \right)$
16. $L_t^f = (1-s) L_{t-1}^f + q_t V_t$

17. $p_t = D\left(\frac{U_t}{V_t}\right)^{\phi-1}$

18. $q_t = D\left(\frac{U_t}{V_t}\right)^{\phi}$

19. $B_{t+1} = (1+r_t^*)B_t - Y_t + C_t + I_t + \eta V_t$

B.3 Solution Method

To evaluate the quantitative predictions of the model we log-linearize the previous system equations around the steady state. As explained before, to ensure stationarity of the model we introduce a risk premium term that depends on the net foreign asset position (see Schmitt-Grohé and Uribe, 2003). We use the algorithm proposed by Schmitt-Grohé and Uribe (2004) to solve the rational expectations model, which provides an efficient implementation of the solution method proposed by Blanchard and Kahn (1980).

C Additional Tables

X	σ_X/σ_Y	Y_{-2}	Y_{-1}	Y	Y_{+1}	Y_{+2}
GDP (Y)	1.00	0.74	0.93	1.00	0.93	0.74
Employment rate (% of POP)	0.58	0.63	0.77	0.83	0.81	0.73
Informal employment (% of POP)	0.71	-0.24	-0.16	-0.07	0.03	0.11
Informality rate (% of employment)	0.78	-0.70	-0.74	-0.70	-0.60	-0.46
- Working for wages	0.64	-0.51	-0.47	-0.33	-0.15	0.00
- Self-employed	1.09	-0.66	-0.72	-0.73	-0.67	-0.56
Out of labor force (% of POP)	0.55	-0.38	-0.42	-0.43	-0.41	-0.36
Unemployment rate (% of labor force)	7.81	-0.60	-0.77	-0.87	-0.89	-0.82

Notes: All series are smoothed out using centered moving averages to clean up for seasonality and detrended using the Hodrick-Prescott filter with parameter 1600. To the best of our ability and taking Bosch and Manacorda (2010) as a guide, we have tried to conform the definition of informality in ENEU to that of the ENOE. POP stands for working-age population.

Table 7: Business Cycle Statistics: Mexico, ENEU Sample (1987.Q1-2004.Q4)