Unemployment Dynamics and Informality in Small Open Economies*

Jaroslav Horvath† Guanyi Yang‡

May 11, 2020

Abstract

Despite the typically more pronounced aggregate fluctuations in emerging market economies (EMEs), this paper documents that EMEs exhibit a lower relative volatility and countercyclicality of unemployment rate than small open advanced economies (AEs). We link these differences to the larger size of informal economy in EMEs. We build a two-sector small open economy model that combines a formal sector featuring labor search frictions with a frictionless informal sector. A larger informal sector amplifies the impact of productivity shocks on formal output, consumption, and employment, while dampening their impact on unemployment. The size of informal sector and its mismeasurement explain a significant fraction of differences in unemployment dynamics across small open economies.

JEL classification: E24, F41, F44, J64.

Keywords: informal economy, labor market frictions, emerging markets, business cycles.

*We would like to thank Yin Germaschewski, John Gibson, Carlos Urrutia, and participants at the 2020 EEA conference for their valuable feedback.

†jaroslav.horvath@unh.edu. Department of Economics, University of New Hampshire, 10 Garrison Avenue, Durham, NH 03824, USA.

‡gyang@stlawu.edu. Department of Economics, St. Lawrence University, 203 Hepburn Hall, 23 Romoda Dr., Canton, NY 13617, USA.

1 Introduction

Compared to the small open advanced economies (AEs), emerging market economies (EMEs) exhibit distinct macroeconomic fluctuations. While most of the literature focuses on explaining the relatively larger aggregate fluctuations in EMEs, in particular, the excessively volatile consumption (e.g., Aguiar and Gopinath, 2007; Neumeyer and Perri, 2005; Uribe and Yue, 2006), only until recently do studies begin to examine the labor market dynamics.[1] The unemployment rate dynamics across small open economies is, however, largely overlooked, despite of its importance in household's welfare and policy making.

In this paper, we provide novel empirical evidence revealing that EMEs display a lower relative variability and countercyclicality of unemployment rate than AEs. Moreover, we link these differences to the size of informal economy, which is substantially larger in EMEs. To rationalize these findings we construct a small open economy model with a search-and-matching friction in the formal sector and a frictionless informal sector. Household members are employed by formal firms, informal firms, or are unemployed, and can issue one-period non-contingent foreign debt. Firms face sector-specific productivity shocks. Formal activity is taxed, whereas informal activity goes unregistered by the government. We calibrate the model to Mexico, a representative EME.

The primary message of this paper is that accounting for the degree of informality in a labor search framework captures important business cycle features across small open economies.[2] Specifically, our main results are threefold. First, our model replicates the cross-country negative relationship between the size of informal sector and the relative volatility and countercyclicality of the unemployment rate. Second, mismeasurement, a feature associated with informality, further helps explain the cross-country unemployment dynamics. Allowing for a part of the informal activity to be measured and captured in national ac-

[1] See, e.g. Boz, Durdu, and Li (2015); Colombo, Menna, and Tirelli (2019); Fernández and Meza (2015); Finkelstein Shapiro (2018); Leyva and Urrutia (2018).

[2] Informality in the model is defined as the fraction of total employment attributed to informal employment.

counts increases the relative unemployment rate volatility and countercyclicality. Third, in addition to the unemployment rate behavior, our baseline model simultaneously captures other salient features of EMEs that are usually difficult to replicate — high output volatility and a more volatile consumption than output.

In exploring the mechanism, our model reveals the central role of informality in propagating sector-specific productivity shocks and in reproducing the cross-country unemployment dynamics. When the economy is hit by a positive formal productivity shock, formal firms increase vacancy postings. The household reallocates members towards formal jobs and substitutes away from informal to formal consumption. As a result, unemployment decreases, while formal employment, output, and consumption increase. Importantly, we find that a larger informal sector leads to a smaller decrease in unemployment and a larger increase in formal output. This is because the household is more willing to substitute between formal and informal employment than between employment and unemployment — a substitution that incurs additional utility cost. A larger informal sector provides a bigger pool of informal workers for reallocation, weakening the dependence on the unemployment margin. Thus, unemployment becomes less volatile and less countercyclical. Similar to Restrepo-Echavarria (2014), a larger informal sector also provides a stronger substitution between formal and informal consumption, generating a more volatile formal consumption.

In addition to their informal counterparts, an increase in informal productivity raises formal employment and output, while lowering unemployment. The reason is that the household substitutes from formal to informal consumption, raising the stochastic discount factor. The expected profitability of formal firms increases, which boosts vacancy postings and generates a small expansion of formal employment and output. Furthermore, the expansion is amplified by an increase of informality. A larger informal sector also dampens the increases in informal employment and output due to diminishing returns to production. The changes in the responses of formal and informal employment cancel out, leaving the unemployment response unchanged. Consequently, the relative volatility and countercyclicality of the unemployment

rate both decrease with informality.

Our paper resides in the small open economy literature understanding the differences in aggregate fluctuations between AEs and EMEs. Majority of the literature focuses on explaining the higher volatility of consumption than output and more strongly countercyclical net exports in EMEs than in AEs. The studies offer explanations by relying on the role of shocks to the level and volatility of interest rate at which countries borrow in international markets (Boz et al., 2015; Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe, 2011; Neumeyer and Perri, 2005; Uribe and Yue, 2006), shocks to the trend component of productivity (Aguiar and Gopinath, 2007; Boz, Daude, and Durdu, 2011; Naoussi and Tripier, 2013), shocks to commodity prices (Bodenstein, Kamber, and Thoenissen, 2018; Fernández, González, and Rodriguez, 2018), and financial frictions (Chang and Fernández, 2013; Fernández and Gulan, 2015; Garcia-Cicco, Pancrazi, and Uribe, 2010). In contrast to the common notion of EMEs exhibiting a larger macroeconomic volatility, we document that the unemployment rate in EMEs tends to be less variable and countercyclical than in AEs. Similarly, Choi and Shim (2018) report a smaller responsiveness of employment and hours worked to technology shocks in developing countries. They attribute it to differential levels of subsistence consumption. We focus on explaining the moments related to the unemployment rate via its link to informal economy. Moreover, by accounting for the large informal sector in EMEs we provide a complementary explanation for the distinct aggregate fluctuations in these countries.

Closely related to our framework, Colombo et al. (2019) analyze the impact of banking crisis and financial frictions on formal and informal labor markets in high-income and low-income countries, while Leyva and Urrutia (2018) emphasize the role of the out-of-labor force margin and interest rate shocks in driving the cyclicality of informality in Mexico. In comparison, we focus on the unemployment dynamics at the business cycle frequency and investigate the propagation of sector-specific productivity shocks. Our work also adds to the growing literature examining the role of informal economy in transmitting domestic

and international shocks (Horvath, 2018; Fernández and Meza, 2015; Restrepo-Echavarria, 2014; Yépez, 2019) and to studies analyzing the relationship between informality, regulation, and labor market frictions (Finkelstein Shapiro, 2018; Ulyssea, 2010). We contribute to this literature in two key respects. First, we highlight the importance of the size and mismeasurement of informal economy to macroeconomic volatility across small open economies, including the novel link between informality and unemployment dynamics. Second, our focus on the unemployment margin allows us to document the unique role of the informal sector in amplifying the responses of formal variables and dampening the responses of informal variables to sector-specific productivity shocks.

The paper proceeds as follows. Section 2 provides empirical evidence on the differences in informality and unemployment dynamics between AEs and EMEs. Section 3 lays out the theoretical framework. Section 4 discusses the calibration method. Section 5 presents the results and Section 6 concludes.

2 Empirical Evidence

In this section, we document significant differences in unemployment dynamics between AEs and EMEs. First, we find the unemployment rate in EMEs to be considerably less volatile and less countercyclical than in AEs. Second, we tie these two patterns to the difference in the size of informal sector, which tends to be markedly larger in EMEs.

We divide small open economies with sufficiently long quarterly unemployment and output data into small open advanced economies (AEs) and emerging market economies (EMEs), following the literature (e.g., Aguiar and Gopinath, 2007; Boz et al., 2015; Epstein, Shapiro, and Gómez, 2019).[3] This yields 14 AEs (Australia, Austria, Belgium, Canada, Denmark, Finland, Ireland, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, and Switzerland) and 15 EMEs (Argentina, Brazil, Chile, Czech Republic, Hungary, Israel, Malaysia,

[3]Slight differences in country coverage are due to unemployment data availability since most of the related literature focusing on business cycles abstracts from unemployment fluctuations.

Mexico, Peru, Philippines, Poland, Slovakia, Slovenia, Thailand, and Turkey). The data is obtained from the International Financial Statistics (IFS) for the 1980:Q1-2018:Q2 sample period.[4] All data series are in real terms, seasonally adjusted using the US Census Bureau's X-12 ARIMA technique, and detrended, after applying the natural logarithm, using the HP filter with a smoothing parameter of 1600.

Table 1 provides an overview of unemployment rate patterns in small open economies at the business cycle frequency. The numbers in brackets denote p-values for the Student's t-test and Mann-Whitney test for equality of means and medians between AEs and EMEs. A few striking differences between the two groups of countries stand out. First, output fluctuations in EMEs are more pronounced than in AEs consistent with the literature (e.g. Neumeyer and Perri, 2005). Second, EMEs exhibit a much lower relative (and absolute) volatility of unemployment rate compared to AEs. The relative standard deviation of unemployment rate to output is, on average, 4.26 in EMEs, whereas it is about 7.67 in AEs. The difference in group means (medians) is statistically significant with a p-value of 0.000 (0.001). Third, the unemployment rate tends to be less countercyclical in EMEs than in AEs. The average correlation between the unemployment rate and output is -0.46 and -0.62 in EMEs and AEs. The correlations are significantly different with a p-value of 0.032 for means and 0.027 for medians.[5]

We hypothesize that the distinct unemployment rate dynamics between AEs and EMEs may be attributed to differences in the size of informal economy, defined as the market-based value-added of productive legal economic activities that go unregistered by the government (Restrepo-Echavarria, 2014).[6] Using data from Table 3.3.6 in Schneider, Buehn, and Montenegro (2010), we find that the average size of informality over the 1999-2007 period in our

[4]The IFS unemployment rate data for Canada and Chile are complemented with data from the OECD and for Thailand from the International Labor Organization (ILO). See Appendix A for country-specific sample windows.

[5]The differences in unemployment rate dynamics between AEs and EMEs are robust to the consideration of a starting year of 1990.

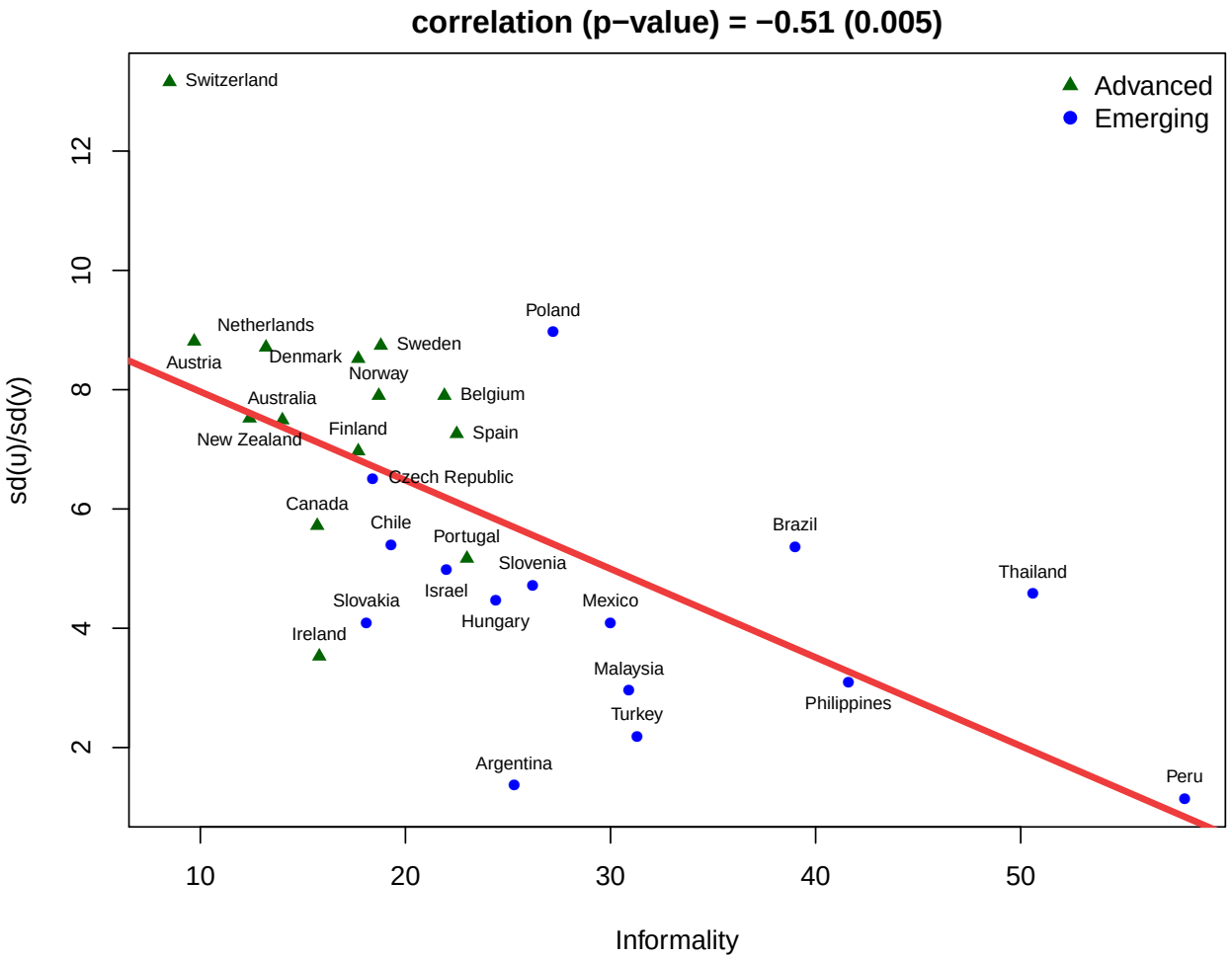
[6]By definition, informal sector excludes home production. See Horvath (2018) for examples of various types of informal activities, and the difference between informal and illegal activities.

Table 1: Unemployment dynamics in small open economies

Country	$\sigma(y)$	$\sigma(u)$	$\sigma(u)/\sigma(y)$	$\rho(u,y)$
Advanced				
Australia	1.20	9.02	7.49	-0.71
Austria	1.06	9.36	8.81	-0.33
Belgium	0.93	7.37	7.90	-0.59
Canada	1.44	8.23	5.72	-0.86
Denmark	1.32	11.21	8.52	-0.68
Finland	2.13	14.82	6.97	-0.72
Ireland	3.04	10.73	3.53	-0.52
Netherlands	1.25	10.92	8.71	-0.70
New Zealand	1.42	10.71	7.52	-0.42
Norway	1.80	14.22	7.90	-0.40
Portugal	1.62	8.35	5.17	-0.80
Spain	1.25	9.09	7.26	-0.72
Sweden	1.65	14.37	8.74	-0.48
Switzerland	1.20	15.74	3.16	-0.70
Mean	1.52	11.01	7.67	-0.62
Median	1.37	10.72	7.71	-0.69
Emerging				
Argentina	4.58	6.27	1.37	-0.62
Brazil	1.90	10.19	5.37	-0.38
Chile	1.80	9.70	5.40	-0.71
Czech Republic	1.87	12.17	6.50	-0.58
Hungary	1.44	6.44	4.47	-0.37
Israel	1.74	8.67	4.98	-0.33
Malaysia	2.44	7.23	2.96	-0.43
Mexico	3.07	12.57	4.09	-0.35
Peru	4.53	5.22	1.15	-0.34
Philippines	2.43	7.51	3.10	-0.05
Poland	1.37	12.30	8.97	-0.39
Slovakia	2.27	9.31	4.09	-0.66
Slovenia	1.95	9.21	4.72	-0.69
Thailand	2.88	13.18	4.58	-0.29
Turkey	4.79	10.48	2.19	-0.78
Mean	2.60	9.36	4.26	-0.46
	[0.004]	[0.103]	[0.000]	[0.032]
Median	2.27	9.31	4.47	-0.39
	[0.001]	[0.158]	[0.001]	[0.027]

Notes: The table shows standard deviations and correlations of output and unemployment rate for small open advanced and emerging market economies. All series are HP-filtered with a smoothing parameter of 1600. The numbers in brackets denote p-values for the Student's t-test and Mann-Whitney test for equality of means and medians between advanced and emerging markets.

Figure 1: Relative volatility of unemployment rate to output versus informal economy



Notes: The figure plots the relative volatility of unemployment rate to output and informality – the size of informal economy as a percentage of GDP.

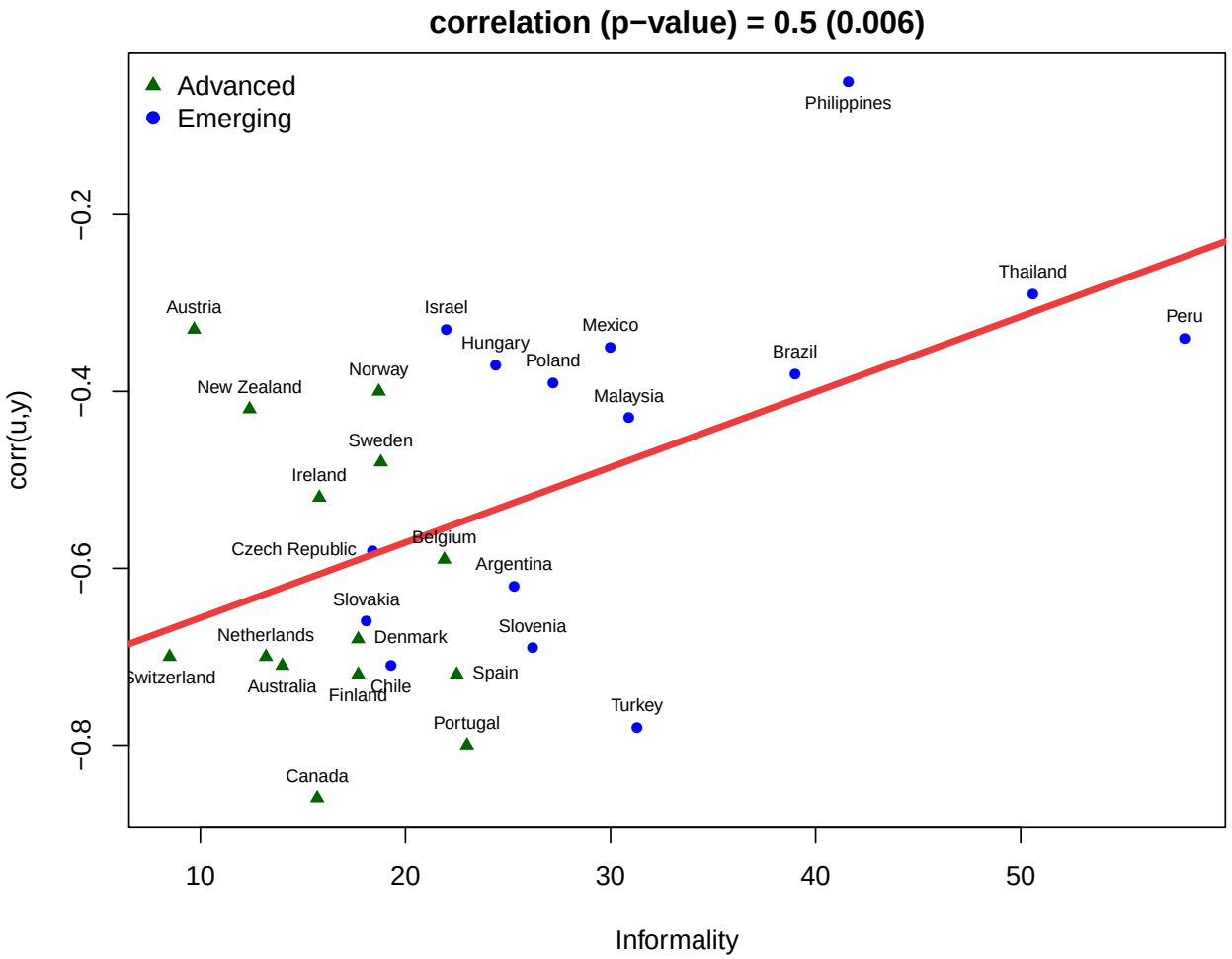
sample of AEs is 16.4% of GDP, while in EMEs it is almost twice as large at 30.6% of GDP.[7]

Figures 1 and 2 further demonstrate the close link between informality and unemployment rate fluctuations in small open economies. Figure 1 shows that the relative volatility of unemployment decreases with the size of informal economy, while Figure 2 reveals that the unemployment rate becomes less countercyclical as the size of informal economy increases.[8] The red lines depict the fitted values from regressing the relative unemployment rate volatil-

[7]There is a high correlation between the Schneider et al. (2010) informality measure and other measures, including constructing informality as a percentage of labor force (Leyva and Urrutia, 2018) or as self-employment (Loayza and Rigolini, 2011).

[8]We also find that the absolute volatility of the unemployment rate decreases with informality.

Figure 2: Correlation between unemployment rate and output versus informal economy



Notes: The figure plots the correlation between unemployment rate and output, and informality – the size of informal economy as a percentage of GDP.

ity, and in turn the correlation of unemployment rate and output, onto the size of informal economy. The regression coefficients (not reported) are found to be highly significant with p-values of 0.000 (Figure 1) and 0.005 (Figure 2). The unconditional correlations, reported above each figure, are also found to be statistically significant.

Next, we construct a theoretical model that accounts for informal economy in order to quantitatively investigate these empirical patterns and the underlying mechanisms between the informal economy and the labor market dynamics over the business cycle.

3 Economic Model

We consider a small-open economy model with two sectors, a formal sector with a labor market search-and-matching friction and a frictionless informal sector. There is a representative household whose members pool their resources together to enjoy leisure and consumption. Members can choose to work in the formal sector, informal sector, or become unemployed. The formal production and labor income, in contrast to the informal ones, are taxed. We abstract from fluctuations in investment and focus on the unemployment dynamics, as in Boz et al. (2015). The sources of aggregate fluctuations in our framework are sector-specific technology shocks. To ease exposition we drop time subscripts and use a prime symbol ($'$) to denote a variable in the next period.

3.1 Search and Matching

Each period, there is a fraction of household members working in the formal sector (n_f), in the informal sector (n_i), and a fraction of members not working (u). Together, $n_f+n_i+u = 1$, implying that u also denotes the unemployment rate in the economy.[9] In the formal sector, firms post vacancies to attract workers for production. Formal workers cannot search on the job. Dissolved formal workers become unemployed or reallocate to the informal sector, and start searching for a formal sector job in the next period.

In line with Cano-Urbina and Gibson (2018), we assume that both the non-working household members and informal sector workers search every period for a formal job. We refer to these two groups as searchers. The measure of vacancies and number of workers searching for formal jobs is each period denoted by v and $u + n_i$. A standard constant-returns-to-scale matching technology, $M(u+n_i, v) = \omega(u+n_i)^{\alpha_m} v^{1-\alpha_m}$, determines the number of job matches each period as a function of vacancies and searchers, with ω denoting the matching efficiency. We define the probability of filling a vacancy as $q \equiv M(u + n_i, v)/v = \omega(v/(u + n_i))^{-\alpha_m} =$

[9] Arseneau and Chugh (2012) and Leyva and Urrutia (2018) examine the impact of out-of-labor force margin on labor market dynamics. We abstract from the margin.

$\omega\theta^{-\alpha_m}$, and the probability that a searcher finds a job as $p \equiv M(u+n_i, v)/(u+n_i) = \omega(v/(u+n_i))^{1-\alpha_m} = \omega\theta^{1-\alpha_m}$. Accordingly, $\theta \equiv v/(u+n_i)$ is defined to be the labor market tightness. A matched formal worker-firm pair is dissolved with an exogenous separation rate s.

3.2 Firms

Firms operate either in a formal sector f or in an informal sector i.[10] Formal labor market has search-and-matching frictions, while informal labor market is frictionless, following Zenou (2008) and Colombo et al. (2019).

3.2.1 Formal firms

Every period, formal firms employ n_f workers, with each worker earning a formal wage rate w_f, and firms paying a tax rate τ_n on their wage bill. Specifically, let $J(n_f, x)$ denote the current value of a formal firm successfully matched with a worker. $x \equiv (z_i, z_f)$ represents the exogenous aggregate state. The formal firm chooses vacancies to maximize its present value of discounted future profits

$$J(n_f, x) = \max_v \{y_f - (1+\tau_n)w_f n_f - \kappa v + E[\rho(x, x')J(n'_f, x')]\} \tag{1}$$

subject to production technology $y_f = z_f(n_f)^{\alpha_f}$ and the evolution of formal employment

$$n'_f = (1-s)n_f + qv. \tag{2}$$

The cost of posting a vacancy per period is denoted by κ, while q denotes the firm's probability of being matched with a worker. y_f captures output produced by formal firms and α_f denotes formal labor share of formal output. $\rho(x, x') \equiv \beta U_{c'_f}/U_{c_f}$ represents the stochastic

[10] The assumption of modeling informality as firms instead of self-employment is in line with La Porta and Shleifer (2008), who provide cross-country evidence that majority of informal firms consist of three or more employees (including the owner).

discount factor with which firms discount their future profits, while β is the household's subjective discount factor and U_{c_f} denotes the marginal utility of formal consumption.

Optimality conditions yield the free-entry condition

$$\frac{\kappa}{q} = E[\rho(x, x')J_{n'_f}(n'_f, x')], \tag{3}$$

and the marginal value of an additional worker to the firm, $J_{n_f}(n_f, x)$,

$$J_{n_f}(n_f, x) = \alpha_f \frac{y_f}{n_f} - (1 + \tau_n)w_f + (1 - s)E[\rho(x, x')J_{n'_f}(n'_f, x')]. \tag{4}$$

The marginal value of a formal worker consists of firm's revenue minus the taxed wage bill plus the expected discounted value of the match continuing next period with a probability of $(1 - s)$.

Combing the firm's two optimality conditions leads to the following job creation condition

$$\frac{\kappa}{q} = E\left[\rho(x, x')\left(\alpha_f \frac{y'_f}{n'_f} - (1 + \tau_n)w'_f + (1 - s)\frac{\kappa}{q'}\right)\right]. \tag{5}$$

The formal firms keep posting vacancies until the cost of an additional worker equals the expected discounted benefit of hiring the additional worker. The formal sector productivity (TFP), z_f, follows a standard AR(1) process $z'_f = \rho_{zf} z_f + \epsilon'_f$, where $\epsilon'_f \overset{iid}{\sim} N(0, \sigma^2_{zf})$. ρ_{zf} captures the persistence and σ_{zf} captures the volatility of the productivity process.

3.2.2 Informal firms

We model the informal sector using a standard frictionless framework. A representative informal firm employs n_i workers and generates output, y_i, with production technology $y_i = z_i(n_i)^{\alpha_i}$. α_i denotes the informal labor share of informal output. The firm pays a

competitive wage rate w_i and chooses n_i to maximize its profit given by:

$$\max_{n_i}[p_c y_i - w_i n_i]. \tag{6}$$

p_c denotes the relative price of informal to formal consumption goods. The efficiency condition yields the standard result that each period the informal wage rate equals to the marginal product of informal output, scaled by the relative consumption price:

$$w_i = p_c \alpha_i z_i (n_i)^{\alpha_i - 1}. \tag{7}$$

The informal sector technology, z_i, follows a standard AR(1) process $z_i' = \rho_{zi} z_i + \epsilon_i'$, where $\epsilon_i' \overset{iid}{\sim} N(0, \sigma_{zi}^2)$, and ρ_{zi} denoting the persistence and σ_{zi} denoting the volatility of the informal technology process.

3.3 Household

The infinitely lived representative household has a unit of time endowment that is allocated to formal employment n_f, informal employment n_i, and leisure time as non-working (unemployment) u, i.e., each period $n_f + n_i + u \leq 1$.[11] The household members pool resources to enjoy leisure and total consumption (c). As in Fernández and Meza (2015) and Colombo, Onnis, and Tirelli (2016), the household aggregates formal and informal consumption according to the constant elasticity of substitution (CES) aggregator:

$$c = [\iota (c_f)^e + (1 - \iota)(c_i)^e]^{1/e}, \tag{8}$$

where $1/(1-e)$ captures the elasticity of substitution between formal (c_f) and informal (c_i) consumption goods, and ι denotes the share of total consumption.

[11] Alternatively, one could think of it as the household assigning n_f share of its members into formal employment, n_i in informal employment, and u in unemployment.

The household maximizes its expected lifetime utility represented as

$$V(n_f, x) = \max_{c_f, c_i, n_i, d'} \{U(c_f, c_i, n_f, n_i) + \beta E[V(n'_f, x')]\} \tag{9}$$

subject to the budget constraint

$$c_f + p_c c_i + d' = (1 + r)d + (1 - \tau_y)w_f n_f + w_i n_i + \Pi, \tag{10}$$

the law of motion of formal employment

$$n'_f = (1 - s)n_f + p(u + n_i), \tag{11}$$

and the time endowment constraint

$$n_f + n_i + u = 1. \tag{12}$$

d' denotes the amount of non-contingent debt the household can issue in the international financial markets at the interest rate $(1 + r)$, τ_y denotes the tax rate on the formal labor income, and Π captures the received profit rebate from formal and informal firms. The right-hand side of equation (10) captures the total household's income, which can be spent on formal and informal consumption, and to pay-off last period's debt. Equation (11) states that the next period's formal employment equals the sum of the formal sector workers whose employment is not terminated in the current period and newly matched workers.

Household's optimality conditions give rise to the following equations:

$$U_{c_i} = p_c U_{c_f}, \tag{13}$$

$$U_{c_f} = \beta E[U_{c'_f}(1 + r')], \tag{14}$$

$$V_{n_f}(n_f, x) = [(1 - \tau_y)w_f - w_i]U_{c_f} + U_{n_f} - U_{n_i} + \beta(1 - s - p)E[V_{n'_f}(n'_f, x')]. \quad (15)$$

The first optimality condition pins down the relative consumption price, which is equated to the marginal rate of substitution between informal and formal consumption. Equation (14) captures the first order condition for debt holdings, while equation (15) represents the marginal value of a matched formal sector worker, $V_{n_f}(n_f, x)$, which is equal to the sum of the wage differential expressed in consumption goods, the difference in disutility of working in the formal versus informal sector, and the next period's expected continuation value.

The utility function takes the standard form:

$$U(c_f, c_i, n_f, n_i) = \log(c) - \varphi(n)^\eta \quad (16)$$

with total consumption (c) given in equation (8), total employment (n) given by $n = n_f + n_i$, $1/(\eta - 1)$ capturing the Frisch elasticity of total labor supply and φ capturing the disutility of work.

Following Schmitt-Grohé and Uribe (2003) and Garcia-Cicco et al. (2010), to achieve stationarity of the small open economy model, the interest rate, r, on issued debt in world capital markets is a combination of a constant world interest rate $\bar{r}$ and an interest rate premium:

$$r = \bar{r} + \psi[exp(\tilde{d} - \bar{d}) - 1], \quad (17)$$

with $\psi > 0$ denoting the interest rate debt elasticity and $\bar{d}$ representing the steady state value of d. $\tilde{d}$ represents the aggregate debt level, which is equal, in equilibrium, to the household's debt level.

3.4 Nash Bargaining

Formal sector wage is set by Nash bargaining between formal sector firms and the household. Firms bargain to maximize their match surplus $J_{n_f}(n_f, x)U_{c_f}$, expressed in utils, while the

household bargains to maximize its match surplus $V_{n_f}(n_f, x)$. Given the formal employment level n_f, exogenous aggregate state x, and formal sector workers' bargaining power $\alpha_b \in (0, 1)$, the formal wage rate solves

$$w_f = \arg\max_{w_f} [J_{n_f}(n_f, x) U_{c_f}]^{1-\alpha_b} [V_{n_f}(n_f, x)]^{\alpha_b}. \tag{18}$$

The optimal condition for the formal wage rate yields

$$(1 + \tau_n)(1 - \alpha_b) V_{n_f}(n_f, x) = (1 - \tau_y) \alpha_b J_{n_f}(n_f, x) U_{c_f}. \tag{19}$$

By plugging the above equation (19) into the household's first order condition (15), combined with the free-entry condition (5) and the marginal value of a formal worker (4), we obtain the following formal wage equation

$$w_f = \frac{\alpha_b}{1 + \tau_n} (\alpha_f \frac{y_f}{n_f} + \kappa\theta) + \frac{1 - \alpha_b}{1 - \tau_y} (w_i - \frac{U_{n_f} - U_{n_i}}{U_{c_f}}). \tag{20}$$

The formal wage rate is a convex combination of two components. The first component captures the marginal product of formal employment and the vacancy posting cost, whereas the second one consists of informal wage rate and marginal rate of substitution between (formal and informal) employment and formal consumption. The weights depend on the worker's bargaining power and tax rates on formal labor income and wage bill.

3.5 Government

The government observes formal activity, which allows it to levy a tax τ_n on the formal labor income and τ_y on the formal wage bill. Each period, the government balances its budget given by

$$g = \tau_n w_f n_f + \tau_y w_f n_f, \tag{21}$$

where the spending, g, is used for unproductive activities. The informal activity goes undetected by the government, and hence, it is not taxed.

3.6 Market clearing

Formal and informal goods markets clear each period

$$y_i = c_i, \tag{22}$$

$$y_f = c_f + g + nx + \kappa v, \tag{23}$$

where net exports, nx, are equal to

$$nx = (1 + r)d - d'. \tag{24}$$

Formal output is used to cover formal consumption, government expenditures, net exports, and vacancy posting costs. As in Restrepo-Echavarria (2014) and Fernández and Meza (2015), we assume, however, that informal output can only be used for informal consumption. This assumption is also supported by the empirical evidence presented by Gasparini and Tornarolli (2009), who report that informal employment accounts for most of the employment in non-tradable sectors in Latin America and the Caribbean.

3.7 Equilibrium

Given formal employment n_f, the equilibrium is a set of quantity sequences $\{c_f, c_i, n_f, n_i, u, v\}$ such that the household maximizes its utility, formal and informal firms maximize their profits, formal employment follows the law of motion in equation (2), government balances its budget, and all markets clear. This yields the following 11 equations and 11 endogenous

variables $\{q, w_f, w_i, \theta, v, u, n_f, n_i, c_f, c_i, d'\}$:

$$U_{c_f} = \beta E[U_{c'_f}(1 + r')] \tag{25}$$

$$n_f + n_i + u = 1 \tag{26}$$

$$n'_f = (1 - s)n_f + qv \tag{27}$$

$$q = \omega\theta^{-\alpha_m} \tag{28}$$

$$\theta = \frac{v}{u + n_i} \tag{29}$$

$$w_i = \frac{U_{c_i}}{U_{c_f}}\alpha_i z_i (n_i)^{\alpha_i - 1} \tag{30}$$

$$w_i + \frac{U_{n_i}}{U_{c_f}} = \frac{\alpha_b}{1 - \alpha_b}\kappa\theta \tag{31}$$

$$w_f = \frac{\alpha_b}{1 + \tau_n}(\alpha_f (n_f)^{\alpha_f - 1} + \kappa\theta) + \frac{1 - \alpha_b}{1 - \tau_y}(w_i - \frac{U_{n_f} - U_{n_i}}{U_{c_f}}) \tag{32}$$

$$z_f (n_f)^{\alpha_f} = c_f + (1 + r)d - d' + \kappa v + \tau_y w_f n_f + \tau_n w_f n_f \tag{33}$$

$$z_i (n_i)^{\alpha_i} = c_i \tag{34}$$

$$\frac{\kappa}{q} = \beta\frac{U_{c'_f}}{U_{c_f}}[\alpha_f (z'_f)(n'_f)^{\alpha_f - 1} - (1 + \tau_n)w'_f + (1 - s)\frac{\kappa}{q'}]. \tag{35}$$

4 Calibration

We solve the model by log-linearizing it around the steady state following the approach of Schmitt-Grohé and Uribe (2004). The parameter values are disciplined using quarterly data for a representative emerging market economy, Mexico, and based on related literature.

Table 2 presents the parameter calibration. Focusing on the preference parameters, the value for the subjective discount factor, β, implies an average country interest rate of 2.2%, constructed using the Emerging Market Bond Index (EMBI) spread data over the 1998Q1-

Table 2: Parameter calibration

parameter	description	value
β	subjective discount factor	0.98
$1/(\eta-1)$	Frisch elasticity of labor supply	0.5
φ	disutility of labor	0.29
$1/(1-e)$	elasticity of substitution between c_f and c_i	12
ι	share of total consumption	0.64
α_b	workers' bargaining power	0.5
α_m	elasticity of matching	0.5
τ_n	tax on formal wage bill	0.11
τ_y	tax on formal labor income	0.07
s	job separation rate	0.06
κ	unit cost of vacancy posting	0.173
ω	scale parameter of matching function	0.294
q	job finding rate	0.7
ψ	interest rate debt elasticity	0.7
α_f	formal labor share of formal output	0.65
α_i	informal labor share of informal output	0.8
ρ_{zf}	persistence of formal technology process	0.95
σ_{zf}	volatility of formal technology process	0.437%
ρ_{zi}	persistence of informal technology process	0.95
σ_{zi}	volatility of informal technology process	0.437%

2016Q4 period.[12] η is set to 3, implying a Frisch labor supply elasticity of 0.5. This is an intermediate value between 1/3 used by Dossche, Lewis, and Poilly (2019) for the Euro Area and 0.6 used by Boz et al. (2015) for a Mexican economy. The elasticity of substitution between formal and informal consumption goods, $1/(1-e)$, is set to 12. Fernández and Meza (2015) choose a value of 8, while Restrepo-Echavarria (2014) argues that the substitutability between formal and informal goods is conceivably higher, and considers formal and informal consumption goods to be perfect substitutes.[13] The values for the disutility of employment, φ, and the share of formal consumption, ι, are calibrated jointly using the equilibrium conditions for the formal wage, informal wage, and the job creation condition.

We set the formal labor market separation rate, s, to 0.06, following Boz et al. (2015), who are motivated by the empirical evidence for Mexico provided in Bosch and Maloney

[12]The data are sourced from Global Financial Data.

[13]See Restrepo-Echavarria (2014) for examples of the high substitutability between formal and informal consumption goods.

(2008). The elasticity of matching, α_m, is set to 0.5, a common value used, for example, in Shimer (2005). To satisfy the Hosios condition, we set the workers' bargaining power, α_b, to 0.5. Consistent with Fernández and Meza (2015), who use annual data for Mexico to estimate the parameters, the tax rates on the formal wage bill (τ_n) and on the formal labor income (τ_y) are set to 0.11 and 0.07. As in Andolfatto (1996) and Boz et al. (2015), the job finding rate, q, and the vacancy posting cost, $\kappa\bar{v}$, are chosen to be 0.7 and 0.01.

The steady-state unemployment rate, $\bar{u}$, equals 3.84%, which is the average unemployment rate in Mexico over the 1987Q1-2018Q2 period. This yields the following steady state level of formed matches $\bar{m} = (1-\bar{u})s = 0.057$. The steady state fraction of time spent working, $(1-\bar{u})$, is allocated to formal and informal employment based on the size of informal sector.[14] In particular, using the Schneider et al. (2010) estimates for Mexico, we set the informal sector size (informality) to 0.3, implying the steady state informal and formal employment of $0.289 = informality(1-\bar{u}) = \bar{n_i}$ and of $0.673 = 1-\bar{u}-\bar{n_i} = \bar{n_f}$. This calibration approach of formal and informal employment in relationship to the unemployment rate is similar to Ulyssea (2010). Schneider et al. (2010) estimate of informality is lower than 0.35 found by Fernández and Meza (2015), who obtain their estimate using national employment surveys for Mexico. We take a conservative stand and use the smaller value obtained from Schneider et al. (2010), who also provide comparable estimates for other countries. The steady state formal employment value leads to steady state vacancies, $\bar{v}$, of 0.058, which implies the unit cost of posting a vacancy, κ, of 0.173, and the matching function scaling parameter, ω, of 0.294. The interest rate debt elasticity, ψ, is fixed at 0.7, which is the estimated value (converted to quarterly frequency) for Mexico in Garcia-Cicco et al. (2010).

The remaining parameters pertain to production. The labor share of output in the formal sector, α_f, is chosen to be 0.65, and in the informal sector, α_i, 0.8, as in Fernández and Meza (2015), who cite empirical evidence of informal firms being more labor intensive. In line with

[14] We do not study the causes of informality in this paper. Hence, the size of informality is calibrated, and varied in later sections to quantify its cross-country impact on unemployment fluctuations. See Aruoba (2018) and Quintin (2008) for potential causes of informality.

Chen, Chu, and Lai (2018), we assume that the formal and informal technology processes are symmetric and uncorrelated. This makes our results more conservative and is also guided by the lack of data availability on the informal technology process. We set the persistence as $\rho_{zf} = \rho_{zi} = 0.95$, in line with the formal technology process estimates for Mexico by Aguiar and Gopinath (2007) and calibrate the TFP volatility such that the model replicates output volatility in Mexico, leading to $\sigma_{zf} = \sigma_{zi} = 0.437\%$. The volatility value is relatively close to the estimate of 0.53% for Mexico reported in Aguiar and Gopinath (2007).

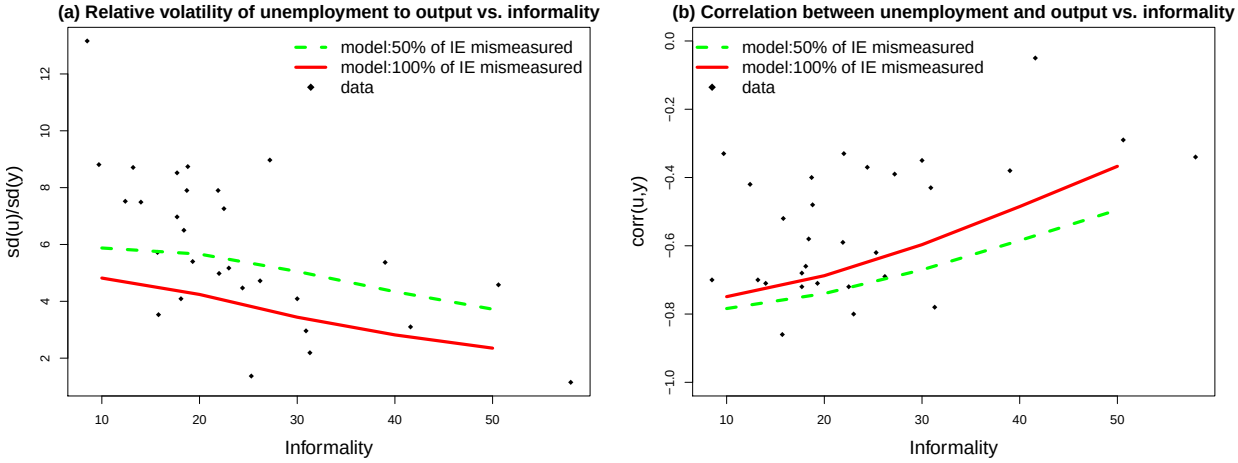
5 Results

This section contrasts the model generated relative volatility and countercyclicality of unemployment rate with their data counterparts for different sizes of informal sector. We examine the mechanism through impulse responses of model variables to formal and informal productivity shocks. We also conduct various robustness checks of our main results.

5.1 Informal economy and unemployment dynamics

First, we vary the size of informality from 0.1 to 0.5 to study its impact on unemployment across small open economies. Then, we examine the imperfect measurement issue associated with informal economy. Many countries employ various approaches to infer the extent of informal activities (e.g. Horvath, 2018; Restrepo-Echavarria, 2014). Fernández and Meza (2015) provide evidence that the Mexican statistical agency (INEGI) was able to capture about 40% of its informal economy in national accounting over the 1998-2003 period. We compare the baseline case of completely not capturing informal output and consumption in country's national accounts (100% mismeasurement), to a case of capturing 50% (50% mismeasurement). The imperfectly measured output, consumption, and net exports each period satisfy the following equations:

Figure 3: Unemployment dynamics and informal economy: Data versus model



Notes: Panel (a) on the left plots the relative volatility of unemployment rate to output versus informality. Panel (b) on the right plots the correlation between unemployment rate and output versus informality. The black diamonds refer to data points. The solid red line denotes model generated values when 100% of informal economy is mismeasured (baseline), while the dashed green line denotes model generated values when 50% of informal economy is mismeasured.

$$y_{IM} = y_f + \phi p_c y_i, \tag{36}$$

$$c_{IM} = c_f + \phi p_c c_i, \tag{37}$$

$$nx_{IM} = y_{IM} - c_{IM} - g - \kappa v, \tag{38}$$

where the parameter ϕ captures the fraction of informal sector included in the national accounts. We set $\phi = 0.5$ and keep it fixed across countries. In Section 5.3, we also account for potential mismeasurement of unemployment and show that our main results remain unchanged.

We report the results in Figure 3. The solid red line graphs the simulation results from the baseline model (100% mismeasurement) and the dashed green line plots the 50% mismeasurement case. The black diamonds represent the data points from Figures 1 and 2. Overall, Figure 3 shows that the size of informal sector plays an important role in driving the cross-country differences in the unemployment rate behavior. The level of mismeasurement further helps to explain the cross-country variation.

Panel (a) in Figure 3 shows that the baseline model generates a strong negative relationship between the size of informal sector and the relative volatility of unemployment rate to output. As we move from the baseline model (100% mismeasurement) to cataloging a half of it (50% mismeasurement), the negative relationship remains. In addition, the relative volatility of unemployment rises for a given size of informality as measurement improves. For the baseline case, the relative volatility ranges from 4.8 (10% informality) to 2.4 (50% informality). For the 50% mismeasurement case it ranges from 5.8 to 3.7.[15]

Panel (b) in Figure 3 highlights that the model also reproduces the positive relationship between unemployment cyclicality and informality: the larger the informal sector, the less countercyclical is the unemployment rate. The 50% mismeasurement case makes the unemployment rate more countercyclical for a given size of informal sector. The correlation between unemployment rate and output goes from -0.75 (-0.78) to -0.37 (-0.49) for the baseline (50% mismeasurement) case.

These findings are consistent with our hypothesis that informal economy explains a significant portion of the cross-country variation in unemployment dynamics. Moreover, its measurement is shown to matter for the unemployment behavior, too. Specifically, we find that the larger the mismeasured fraction of the informal sector is, the lower the relative volatility and countercyclicality of the unemployment rate are. This complements the evidence in Restrepo-Echavarria (2014), who shows that informality and its mismeasurement contribute to higher relative volatility of consumption to output.

The baseline case in Table 3 shows that the model successfully reproduces additional business cycle moments of the Mexican economy, representative features of EMEs that are typically difficult to generate. The first column presents the empirical moments. The last two columns report the model-generated moments for the baseline and 50% mismeasurement cases. Several results emerge. First, the model captures well the unemployment volatility and countercyclicality, albeit it overestimates the magnitude of the countercyclicality. Sec-

[15]We also find that the absolute volatility of unemployment decreases with informality.

Table 3: Business cycle moments in Mexico: Data versus model

Moment	Data	Baseline (100% mismeasurement)	50% mismeasurement
$\sigma(y)$	3.07	3.07	2.09
$\sigma(c)/\sigma(y)$	1.23	1.06	0.88
$\sigma(u)/\sigma(y)$	4.09	3.44	5.05
$\sigma(v)/\sigma(y)$	–	4.88	7.16
$\rho(c,y)$	0.91	1.00	0.88
$\rho(u,y)$	-0.35	-0.60	-0.67
$\rho(v,y)$	–	0.82	0.84
$\rho(u,v)$	–	-0.29	-0.29

Notes: The table reports the business cycle moments for Mexico. $\sigma(x)$ refers to a standard deviation of variable x. $\rho(x,z)$ refers to a correlation between variables x and z. Baseline model considers the case when none of the informal sector is captured in national statistics and unemployment is measured perfectly. In this case, y, c, nx, u denote y_f, c_f, nx, u in the main text. Imperfect measurement considers a scenario when 50% of informal sector is captured in national statistics and unemployment is measured perfectly, i.e., y, c, nx, u denote $y_{IM}, c_{IM}, nx_{IM}, u$ in the main text. Given the lack of data, we do not report the vacancy-related moments.

ond, in line with the empirical evidence in Table 1, the volatility of output decreases with improved measurement of informal sector. This suggests an additional explanation for the difference in output volatility between AEs and EMEs, to the extent that AEs devote relatively more resources to the measurement of their informal economy and, hence, capture a larger share of it. Third, the model generates a more volatile consumption than output, a salient business cycle feature of EMEs. The relative volatility of consumption decreases with improvements in measuring the informal sector, as in Restrepo-Echavarria (2014). In our case, it becomes less than one when a half of the informal sector is accounted for, capturing another difference in the business cycle dynamics between EMEs and AEs (e.g. Neumeyer and Perri, 2005; Aguiar and Gopinath, 2007). Lastly, the vacancy postings exhibit a relatively high variability, procyclicality, and a negative correlation with unemployment.[16] The vacancy postings exhibit a relatively high volatility and procyclicality.

[16]We also find that total employment displays low volatility and cyclicality, driven by volatile formal and informal employment; the former being highly procyclical while the latter being countercyclical as documented for Mexico by Fernández and Meza (2015).

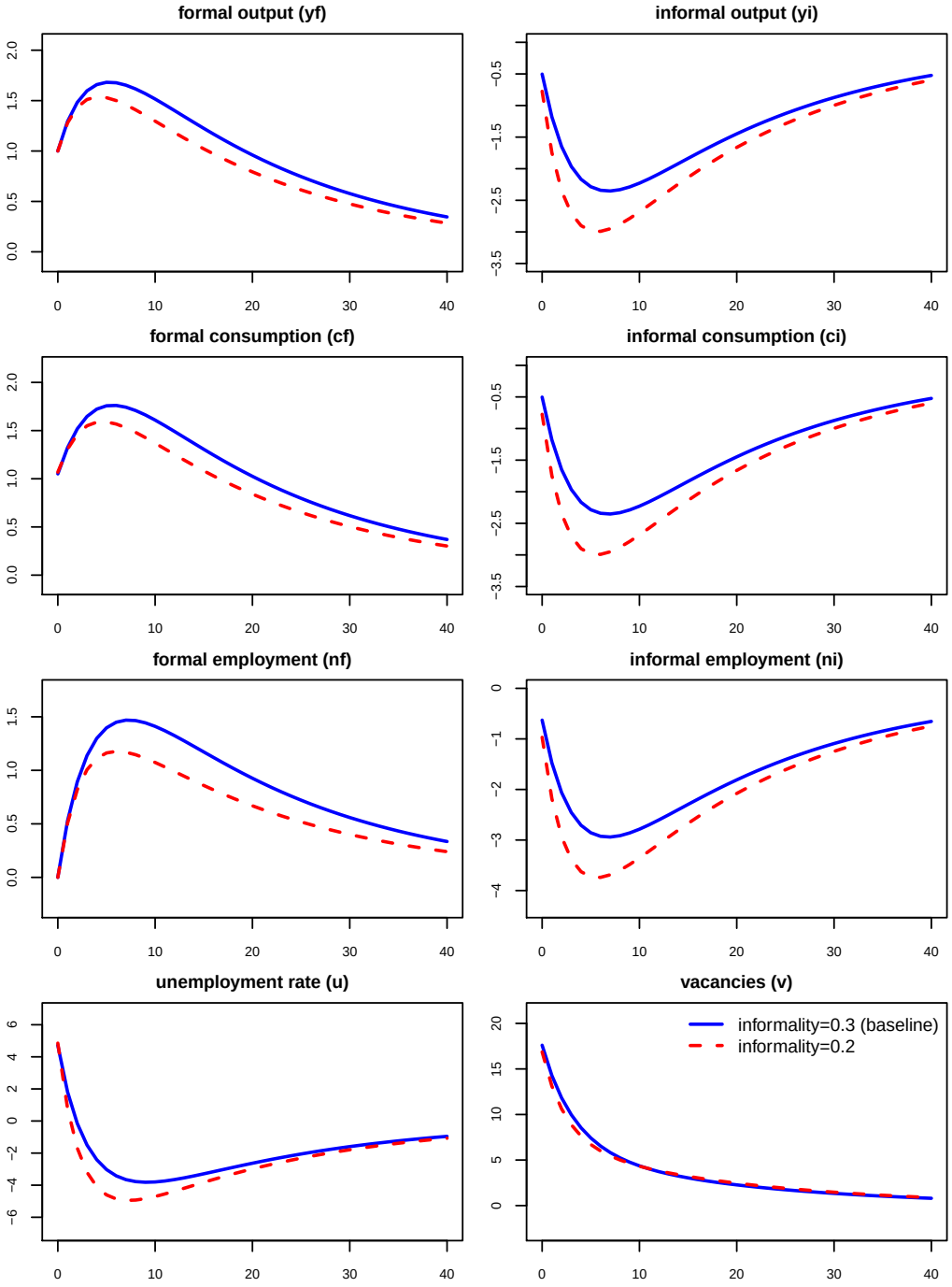
5.2 Mechanism

In this section, we show how sector-specific productivity shocks transmit through the economy. Because of the asymmetry of the frictions between formal and informal labor markets, the transmission of the shocks depends on whether the shock originates in the formal or informal sector. By varying the size of informal sector, we illustrate the mechanism behind the impact of informal sector on the unemployment dynamics.

Figure 4 presents the impulse response functions to a one percent increase in the formal sector productivity. All values are plotted in percentage deviations from steady state. The blue solid line represents the baseline model responses. Formal output, consumption, and employment increase gradually in response to the shock, before returning back to their steady state values. As the shock hits the economy, formal firms increase vacancy postings and the household substitutes informal for formal consumption. However, the search friction prevents the immediate adjustment in the formal employment. Together with the initial drop in informal employment, the unemployment rate increases on impact. From the first period onward, formal employment gradually increases as informal sector workers and unemployed members reallocate to formal sector to take advantage of the relatively higher formal sector productivity. This, in turn, lowers the unemployment rate. The substitution to formal consumption and employment leads to a proportional decrease in informal consumption, employment and output. Once the formal labor market fully absorbs the shock, all series gradually return to their steady state values.

Our model allows for an additional source of flows to (and out of) formal employment from (to) the informal sector, compared to a standard one-sector search-and-match framework. The size of informal sector provides a key role in propagating the shocks throughout the economy. Figure 4 compares the baseline economy with 30% of total employment being informal (solid line) to an economy with informality of 20% (dashed line). A smaller informal sector leads to a larger decrease in unemployment and a smaller increase in formal output. This is because the household is more willing to substitute between formal and informal

Figure 4: Impulse responses to a positive formal productivity shock



Notes: The figure plots the impulse response functions of formal and informal output, consumption, employment, unemployment rate, and vacancies to a one percent increase in the formal productivity. The solid line denotes the baseline model with an informal sector size of 0.3. The dashed line denotes a model with an informal sector size of 0.2.

employment than between employment and unemployment. The substitution between employment and unemployment incurs additional utility cost. The lower informality implies a smaller pool of informal workers for reallocation to the formal sector, forcing the household to depend more on the unemployed members for adjustment when the formal productivity increases. This is reflected in a larger drop in the informal employment and simultaneously in a less pronounced increase in the formal employment. As a result, more unemployed members are reallocated to the formal sector when the shock hits, leading to a more volatile and countercyclical unemployment rate.

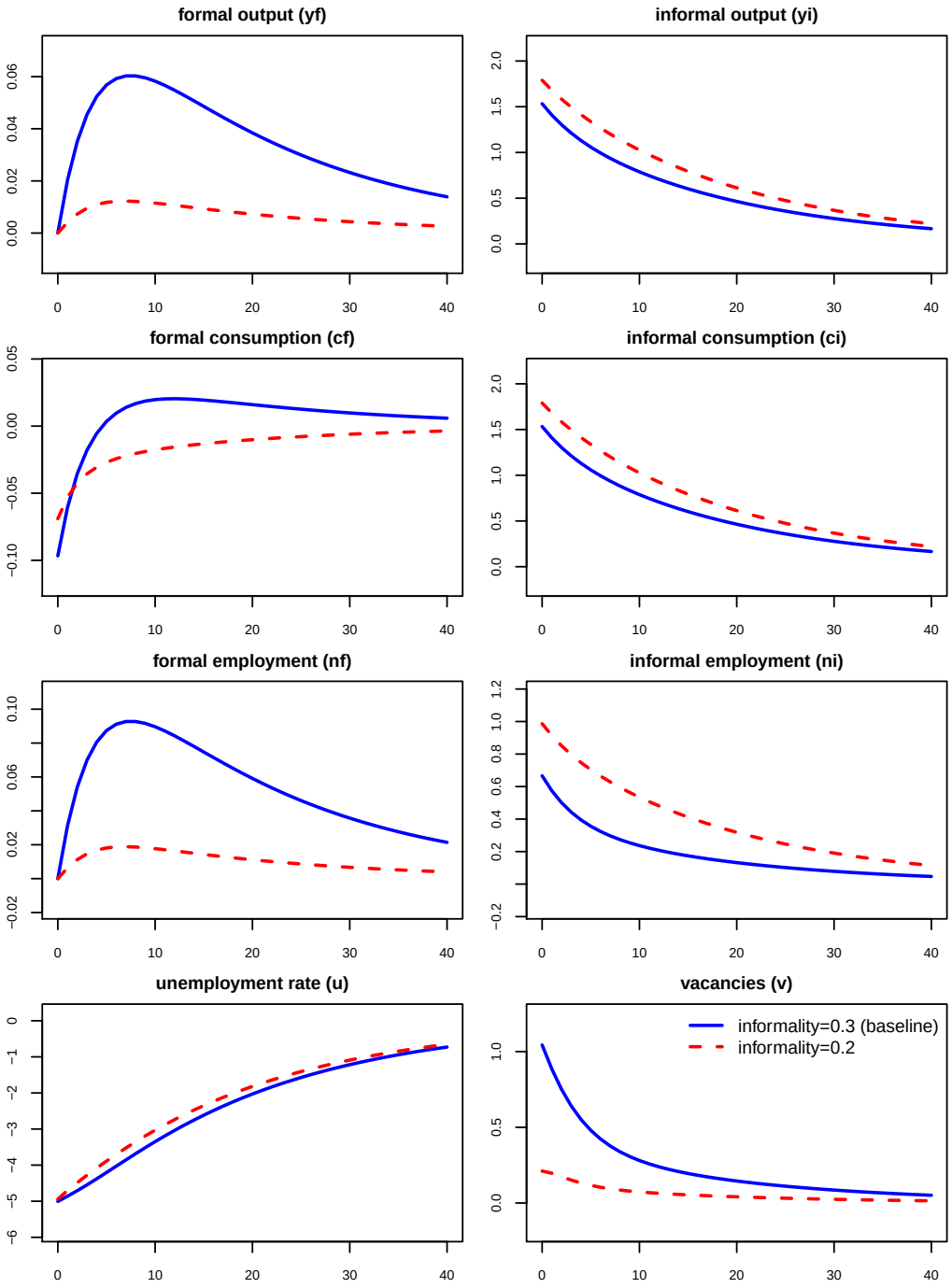
Figure 5 shows the impulse responses to a one percent increase in informal productivity. The shock makes informal sector relatively more productive. It incentivizes the household to substitute away from formal to informal consumption, and to reallocate unemployed members to the informal sector. This raises informal employment, consumption, and output on impact, and decreases formal consumption. The response of formal and informal consumption raises the stochastic discount factor, which lowers the rate at which formal firms discount their future payoffs and, hence, makes vacancy postings more profitable – a link highlighted in the free-entry condition in equation (5). The resultant increase in vacancy postings, gradually stimulates formal employment and output.[17]

Similarly to Figure 4, Figure 5 shows that the size of informal sector dictates the strength of shock propagation. In particular, formal output, consumption, and employment become more pronounced when the size of informality increases from 20 to 30 percent. Informal responses, however, become less pronounced due to a bigger pool of informal workers and the diminishing returns to production. The unemployment rate's response, however, remains largely unchanged.[18] The reason is two offsetting forces. A bigger informal sector leads to a smaller *percentage* increase in informal employment, but also to a larger increase in formal employment brought about by a more substantial increase in vacancies. The two effects

[17]Note that these increases are much smaller compared to the formal productivity shock. This is because an increase in informal productivity creates a relative decrease in formal productivity.

[18]The response remains very similar when considering an informality of 40 percent.

Figure 5: Impulse responses to a positive informal productivity shock



Notes: The figure plots the impulse response functions of formal and informal output, consumption, employment, unemployment rate, and vacancies to a one percent increase in the informal productivity. The solid line denotes the baseline model with an informal sector size of 0.3. The dashed line denotes a model with an informal sector size of 0.2.

largely cancel out, implying a very similar unemployment response. Note, however, that the relative unemployment volatility and countercyclicality both decrease with informality because of the relatively larger increase in output.

5.3 Sensitivity analysis

We conduct sensitivity analysis for the baseline results in Table 4 by considering the possibility of mismeasurement of the unemployment rate and by varying several key parameters related to the formal and informal employment. Our main results, replicating the EMEs' unemployment dynamics, continue to hold.

First, we consider the possibility that unemployment may be mismeasured. Column 2 (u_{IMi}) presents results of attributing 5% of the informal workers to unemployment. The imperfectly measured unemployment is given by $u_{IMi} = 1 - n_f - (1 - \phi_u)n_i$, where $\phi_u = 0.05$. Alternatively, informal workers can also simultaneously hold jobs in the formal sector. Column 3 (u_{IMf}) considers a case of counting 5% of workers as both formal and informal. The unemployment is in this case calculated as $u_{IMf} = 1 - n_f - (1 + \phi_u)n_i$, where $\phi_u = 0.05$. Compared to the baseline model, the relative standard deviation of unemployment to output decreases and the countercyclicality increases for the u_{IMi} case. The moments change in the opposite direction for the u_{IMf} case. These results are driven by the volatility of informal employment and its negative relationship with formal employment, which are scaled up or down based on the unemployment mismeasurement.

In Column 4 we lower the elasticity of substitution between formal and informal consumption, $\frac{1}{1-e}$, to 6 from the benchmark value of 12. A similar lower value is usually considered for the elasticity between market and non-market consumption goods in the home production literature (e.g. Benhabib, Rogerson, and Wright, 1991; Chen et al., 2018), which is conceivably lower than the one between formal and informal goods, as pointed out by Restrepo-Echavarria (2014). Theoretically, a household with a lower $\frac{1}{1-e}$ is less willing to substitute between formal and informal consumption goods when the relative price of

Table 4: Business cycle moments in Mexico: Sensitivity analysis

Moment	(1) Baseline	(2) u_{IMi}	(3) u_{IMf}	(4) $\frac{1}{1-e}=6$	(5) $\frac{1}{\eta-1}=0.33$	(6) $s=0.04$	(7) $\kappa=0.2$	(8) $\alpha_i=0.7$
$\sigma(y)$	3.07	3.07	3.07	3.12	3.30	2.72	2.96	3.03
$\sigma(c)/\sigma(y)$	1.06	1.06	1.06	1.04	0.97	1.07	1.05	1.04
$\sigma(u)/\sigma(y)$	3.44	2.79	5.03	4.04	3.09	3.56	3.42	4.22
$\sigma(v)/\sigma(y)$	4.88	4.88	4.88	4.91	5.22	5.52	4.70	4.86
$\rho(c,y)$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$\rho(u,y)$	-0.60	-0.71	-0.45	-0.78	-0.72	-0.39	-0.55	-0.76
$\rho(v,y)$	0.82	0.82	0.82	0.82	0.80	0.78	0.83	0.82
$\rho(u,v)$	-0.29	-0.38	-0.16	-0.46	-0.41	-0.02	-0.26	-0.44

Notes: Baseline model considers the case when none of the informal sector is captured in national statistics and unemployment is measured perfectly. In this case, y, c, nx, u denote y_f, c_f, nx, u in the main text. u_{IMi} considers a scenario when 5% of informal workers (n_i) is not captured in total employment, i.e., $u_{IMi} = 1 - n_f - (1 - 0.05)n_i$. u_{IMf} considers a scenario when 5% of informal workers (n_i) is doublecounted in formal employment and, hence, they are excluded from unemployment, i.e., $u_{IMf} = 1 - n_f - (1 + 0.05)n_i$.

consumption changes, which reduces relative consumption volatility. Moreover, the lower consumption elasticity weakens the shock transmission between formal and informal sectors, as described in impulse responses, rendering the pool of unemployed a more important channel for labor adjustment. Therefore, it results in a higher unemployment volatility, and a higher countercyclicality of unemployment.

Column 5 in Table 4 decreases the Frisch elasticity, $\frac{1}{\eta-1}$, to 0.33 from the baseline value of 0.5. This amounts to setting $\eta = 4$ as in, for example, Dossche et al. (2019). The lower Frisch elasticity reduces the responsiveness of both formal and informal labor supply, which reduces the fluctuations in unemployment and consumption, and increases output variability. As a result, we observe a decrease in the relative volatility of unemployment and consumption, and a larger countercyclicality of unemployment.

In Column 6, we experiment with lowering the job separation rate s to 0.04 from 0.06, closer to the values used by Finkelstein Shapiro (2018). A lower job separation rate increases the continuation value for formal firms and makes vacancies more responsive to shocks. The continuation value for a formal worker also increases relative to the baseline case, as formal employment spells increase. Thus, lowering s leads to a lower output volatility, higher relative volatility of vacancies, unemployment, and a lower countercyclicality of unemployment.

When we raise the vacancy posting cost κ to 0.2 from 0.173, we find that the output volatility decreases as the firms are more reluctant to adjust their vacancies in response to shocks due to higher posting costs and longer employment duration. This decreases the likelihood of finding a job in the formal sector and, hence, also the flows between formal employment and unemployment.

Lastly, we consider a less labor intensive informal production by setting α_i to 0.7 instead of 0.8. A lower share of labor in the informal production mitigates the link between informal employment and output fluctuations, implying a weaker substitution between formal and informal labor, and leaving unemployment as the main source of absorbing shocks. As a result, unemployment volatility and countercyclicality both increase.

Overall, the section shows that the baseline model-generated business cycle moments are robust to reasonable changes in key parameters pertinent to the labor search and informal economy literature.

6 Conclusion

We document significant differences in unemployment rate dynamics between small open advanced economies (AEs) and emerging market economies (EMEs). We link these differences to the size of informal economy. In particular, we show that the size of informal economy is negatively related to the relative volatility of unemployment rate to output, and the countercyclicality of unemployment rate. Our small-open economy two-sector model with asymmetric frictions between formal and informal labor markets replicates the documented cross-country unemployment rate dynamics, along with cross-country differences in consumption and output volatility. In addition to the flow between formal employment and unemployment, households have an alternative choice of working in the informal sector. A larger informal sector offers a stronger substitution between formal and informal employment over the business cycle, amplifying fluctuations in formal output, consumption and

employment, while dampening fluctuations in unemployment.

Appendix A Data

In Table A.1, we provide the country-specific sample windows for the output and unemployment rate data used in our empirical analysis. The correlations reported in Table 1 between output and unemployment rate are computed on the overlapping sample.

Table A.1: Sample windows for output and unemployment rate

Country	Sample(y)	Sample(u)	Country	Sample(y)	Sample(u)
Advanced			**Emerging**		
Australia	1980:1-2018:1	1980:1-2018:2	Argentina	1993:1-2017:1	2002:4-2017:2
Austria	1980:1-2018:2	1980:1-2018:2	Brazil	1995:1-2017:3	1981:1-2018:1
Belgium	1980:1-2018:2	1983:1-2017:4	Chile	1996:1-2017:3	1986:1-2018:2
Canada	1980:1-2017:4	1980:1-2018:2	Czech Republic	1995:1-2018:2	1993:1-2018:1
Denmark	1980:1-2018:2	1981:1-2017:4	Hungary	1991:1-2018:2	1992:1-2018:1
Finland	1980:1-2018:2	1988:1-2018:1	Israel	1980:1-2018:1	1990:1-2018:1
Ireland	1990:1-2018:2	1983:1-2017:4	Malaysia	1991:1-2017:1	1998:1-2017:4
Netherlands	1980:1-2018:2	1983:1-2018:2	Mexico	1981:1-2018:1	1987:1-2018:2
New Zealand	1980:1-2018:2	1986:1-2018:2	Peru	1980:1-2017:1	2001:2-2017:3
Norway	1980:1-2017:1	1980:1-2017:4	Philippines	1981:1-2017:3	1998:1-2018:1
Portugal	1980:1-2018:2	1992:1-2017:4	Poland	1995:1-2018:2	1992:2-2017:3
Spain	1980:1-2018:2	1986:2-2018:1	Slovakia	1995:1-2018:2	1994:1-2017:4
Sweden	1980:1-2017:2	1983:1-2018:2	Slovenia	1995:1-2018:2	1996:1-2017:4
Switzerland	1980:1-2018:2	1993:1-2018:2	Thailand	1993:1-2017:3	1998:1-2018:1
			Turkey	1987:1-2018:2	2000:1-2018:1

References

Aguiar, M. and G. Gopinath (2007). Emerging market business cycles: The cycle is the trend. *Journal of Political Economy 115*(1), 69–102.

Andolfatto, D. (1996). Business cycles and labor-market search. *American Economic Review*, 112–132.

Arseneau, D. M. and S. K. Chugh (2012). Tax smoothing in frictional labor markets. *Journal of Political Economy 120*(5), 926–985.

Aruoba, S. B. (2018). Institutions, tax evasion and optimal policy. *Working Paper*.

Benhabib, J., R. Rogerson, and R. Wright (1991). Homework in macroeconomics: Household production and aggregate fluctuations. *Journal of Political Economy 99*(6), 1166–1187.

Bodenstein, M., G. Kamber, and C. Thoenissen (2018). Commodity prices and labour market dynamics in small open economies. *Journal of International Economics 115*, 170–184.

Bosch, M. and W. Maloney (2008). *Cyclical movements in unemployment and informality in developing countries*. The World Bank.

Boz, E., C. Daude, and C. B. Durdu (2011). Emerging market business cycles: Learning about the trend. *Journal of Monetary Economics 58*(6-8), 616–631.

Boz, E., C. B. Durdu, and N. Li (2015). Emerging market business cycles: The role of labor market frictions. *Journal of Money, Credit and Banking 47*(1), 31–72.

Cano-Urbina, J. and J. Gibson (2018). Assessing the impact of informal sector employment on young less-educated workers. *Working Paper*.

Chang, R. and A. Fernández (2013). On the sources of aggregate fluctuations in emerging economies. *International Economic Review 54*(4), 1265–1293.

Chen, K.-J., A. C. Chu, and C.-C. Lai (2018). Home production and small open economy business cycles. *Journal of Economic Dynamics and Control 95*, 110–135.

Choi, S. and M. Shim (2018). Labor market dynamics in developing economies: The role of subsistence consumption. *Working Paper*.

Colombo, E., L. Menna, and P. Tirelli (2019). Informality and the labor market effects of financial crises. *World Development 119*, 1–22.

Colombo, E., L. Onnis, and P. Tirelli (2016). Shadow economies at times of banking crises: Empirics and theory. *Journal of Banking & Finance 62*, 180–190.

Dossche, M., V. Lewis, and C. Poilly (2019). Employment, hours and the welfare effects of intra-firm bargaining. *Journal of Monetary Economics 104*, 67–84.

Epstein, B., A. F. Shapiro, and A. G. Gómez (2019). Global financial risk, aggregate fluctuations, and unemployment dynamics. *Journal of International Economics 118*, 351–418.

Fernández, A., A. González, and D. Rodriguez (2018). Sharing a ride on the commodities roller coaster: Common factors in business cycles of emerging economies. *Journal of International Economics 111*, 99–121.

Fernández, A. and A. Gulan (2015). Interest rates, leverage, and business cycles in emerging economies: The role of financial frictions. *American Economic Journal: Macroeconomics 7*(3), 153–88.

Fernández, A. and F. Meza (2015). Informal employment and business cycles in emerging economies: The case of mexico. *Review of Economic Dynamics 18*(2), 381–405.

Fernández-Villaverde, J., P. Guerrón-Quintana, J. F. Rubio-Ramírez, and M. Uribe (2011). Risk matters: The real effects of volatility shocks. *American Economic Review 101*(6), 2530–61.

Finkelstein Shapiro, A. (2018). Labor force participation, interest rate shocks, and unemployment dynamics in emerging economies. *Journal of Development Economics 133*(C), 346–374.

Garcia-Cicco, J., R. Pancrazi, and M. Uribe (2010). Real business cycles in emerging countries? *American Economic Review 100*(5), 2510–31.

Gasparini, L. and L. Tornarolli (2009). Labor informality in Latin America and the Caribbean: Patterns and trends from household survey microdata. *Desarrollo y Sociedad* (63), 13–80.

Horvath, J. (2018). Business cycles, informal economy, and interest rates in emerging countries. *Journal of Macroeconomics 55*, 96–116.

La Porta, R. and A. Shleifer (2008). The unofficial economy and economic development. *Brookings Papers on Economic Activity*.

Leyva, G. and C. Urrutia (2018). Informality, labor regulation, and the business cycle. *Banco de México Working Paper 2018-19*.

Loayza, N. V. and J. Rigolini (2011). Informal employment: Safety net or growth engine? *World Development 39*(9), 1503–1515.

Naoussi, C. F. and F. Tripier (2013). Trend shocks and economic development. *Journal of Development Economics 103*, 29–42.

Neumeyer, P. A. and F. Perri (2005). Business cycles in emerging economies: The role of interest rates. *Journal of Monetary Economics 52*(2), 345–380.

Quintin, E. (2008). Contract enforcement and the size of the informal economy. *Economic Theory 37*(3), 395–416.

Restrepo-Echavarria, P. (2014). Macroeconomic volatility: The role of the informal economy. *European Economic Review 70*, 454–469.

Schmitt-Grohé, S. and M. Uribe (2003). Closing small open economy models. *Journal of International Economics 61*(1), 163–185.

Schmitt-Grohé, S. and M. Uribe (2004). Solving dynamic general equilibrium models using a second-order approximation to the policy function. *Journal of Economic Dynamics and Control 28*(4), 755–775.

Schneider, F., A. Buehn, and C. E. Montenegro (2010). Shadow economies all over the world: New estimates for 162 countries from 1999 to 2007. *World Bank policy research working paper* (5356).

Shimer, R. (2005). The cyclical behavior of equilibrium unemployment and vacancies. *American Economic Review 95*(1), 25–49.

Ulyssea, G. (2010). Regulation of entry, labor market institutions and the informal sector. *Journal of Development Economics 91*(1), 87–99.

Uribe, M. and V. Z. Yue (2006). Country spreads and emerging countries: Who drives whom? *Journal of International Economics 69*(1), 6–36.

Yépez, C. A. (2019). Informality and international business cycles. *Journal of International Financial Markets, Institutions and Money 62*, 252–263.

Zenou, Y. (2008). Job search and mobility in developing countries. theory and policy implications. *Journal of Development economics 86*(2), 336–355.