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Unemployment dynamics and informality in small open economies[☆]

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ABSTRACT

Despite the typically more pronounced aggregate fluctuations in emerging market economies (EMEs), this paper documents that EMEs exhibit lower relative volatility and countercyclicality of the unemployment rate than small open advanced economies. We link these differences to the larger informal economy in EMEs. We build a 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 and interest rate shocks on formal output, consumption, and employment, while dampening their impact on unemployment. Varying the degree of informality explains a significant fraction of differences in unemployment dynamics across small open economies.

1. Introduction

Compared to small open advanced economies (AEs), emerging market economies (EMEs) exhibit distinct macroeconomic fluctuations. While most of the literature focuses on explaining relatively larger aggregate fluctuations in EMEs, especially excessively volatile consumption (e.g., Aguiar and Gopinath, 2007; Neumeyer and Perri, 2005; Uribe and Yue, 2006), only recently have studies begun to examine labor market dynamics.[1] Unemployment rate dynamics in small open economies, however, are largely overlooked, despite their importance in understanding household welfare and policy making.

In this paper, we provide novel empirical evidence revealing that EMEs display a lower relative variability and countercyclicality of the unemployment rate than AEs. We link these differences to the size of the informal economy, which is substantially larger in EMEs. To rationalize the findings, we construct a small open economy model with search-and-matching frictions in the formal sector and a frictionless informal sector. Household members are employed by formal firms, informal firms, or unemployed, and can issue one-period non-contingent foreign debt, subject to country interest rate shocks. Firms face sector-specific productivity shocks. 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 differences in 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 the informal sector and the relative volatility and countercyclicality of the unemployment rate. Second, in addition to the unemployment rate behavior, our baseline model

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[1] See, e.g., Altug and Kabaca (2017), Boz et al. (2015), Colombo et al. (2019), Fernández and Meza (2015), Finkelstein Shapiro (2018) and Leyva and Urrutia (2020).

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

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simultaneously captures other salient features of EMEs that are usually difficult to replicate, including the excessive volatility of the consumption and countercyclicality of the trade balance-to-output ratio. Third, mismeasurement, a key feature of informality, further helps explain the differences in unemployment rate dynamics across small open economies. In exploring the mechanism, our model reveals the central role of informality in propagating sector-specific productivity shocks and interest rate shocks, and in reproducing cross-country unemployment rate 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 a larger informal sector provides a bigger pool of informal workers for reallocation, weakening the dependence of labor adjustment 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 relative to formal output.

A positive *informal* productivity shock increases employment and output, interestingly, in both sectors, while lowering unemployment. The household substitutes from formal to informal consumption when informal productivity increases, raising the stochastic discount factor. Formal firms discount their future profits at a lower rate, which boosts vacancy postings and generates a small expansion of formal employment and output. Furthermore, the expansion is amplified by an increase in informality. A larger informal sector dampens the increases of informal employment and output due to the diminishing returns to production. The changes in the responses of formal and informal employment offset each other, leaving the unemployment response largely unchanged. Consequently, the relative volatility and countercyclicality of the unemployment rate both decrease with informality.

When the economy receives a positive *interest rate* shock, formal firms discount their expected future profits at a higher rate, which leads them to reduce their vacancy postings. In response, the household reallocates resources to the relatively more profitable informal sector. The unemployment rate initially drops, because of the increase of informal employment and the lack of response in formal employment due to labor market frictions. In the next period, the unemployment rate starts to increase as formal employment adjusts. Similarly to the impact of productivity shocks, a larger informal sector increases the pool of informal workers available for sectoral reallocation, and hence exacerbates the formal output, consumption, and employment responses, while muting the response of the unemployment rate.

Our paper resides in the small open economy literature understanding the differences in aggregate fluctuations between AEs and EMEs. The majority of the literature focuses on explaining the higher volatility of consumption than of output and the more strongly countercyclical net exports in EMEs than in AEs. The studies offer explanations by relying on shocks to the level and volatility of the interest rate at which countries borrow in international markets (Boz et al., 2015; Fernández-Villaverde et al., 2011; Neumeyer and Perri, 2005; Rothert, 2020; Uribe and Yue, 2006), shocks to the trend component of productivity (Aguiar and Gopinath, 2007; Boz et al., 2011; Naoussi and Tripier, 2013), commodity prices (Bodenstein et al., 2018; Charnavoki and Dolado, 2014; Fernández et al., 2018), the role of financial frictions (Chang and Fernández, 2013; Fernández and Gulan, 2015; Garcia-Cicco et al., 2010), and government transfers (Michaud and Rothert, 2018). In contrast to the common notion of EMEs exhibiting larger macroeconomic volatility, we document that the unemployment rate in EMEs tends to be less variable and less countercyclical than in AEs. Germane to our analysis, Choi and Shim (2018) report smaller responsiveness of employment and hours worked to technology shocks in developing than in high-income 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 the informal economy and center our attention on small open economies. By accounting for the large informal sector in EMEs, we provide a complementary explanation for the distinct aggregate fluctuations in these countries.

Similarly to our framework, Colombo et al. (2019) analyze the impact of banking crises and financial frictions on formal and informal labor markets in high-income and low-income countries, while Leyva and Urrutia (2020) 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 behavior of informal firms facing a probability of being audited by the government, instead of self-employed entrepreneurs. Our work also adds to the growing literature examining the role of the informal economy in transmitting domestic and international shocks (Fernández and Meza, 2015; Horvath, 2018; Restrepo-Echavarria, 2014; Yépez, 2019) and to studies analyzing the relationship between informality, regulation, and labor market frictions (Finkelstein Shapiro, 2018; Lama and Urrutia, 2011; Ulyssea, 2010; Yang, 2018). We contribute to this literature in two key respects. First, we highlight the importance of the size and mismeasurement of the informal economy to macroeconomic volatility across small open economies, including the novel link between informality and unemployment dynamics. Second, our focus on the unemployment rate 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 and interest rate 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 main results. Section 6 considers extensions and sensitivity analysis of the baseline model. Section 7 concludes.

2. Empirical evidence

In this section, we document significant differences in unemployment rate dynamics between AEs and EMEs. First, we demonstrate that the unemployment rate in EMEs is considerably less volatile and less countercyclical than in AEs. Second, we tie these two patterns to the size of informal sector, which is typically much larger in EMEs.

Table 1
Unemployment rate dynamics in small open economies.

Country	$\sigma(y)$	$\sigma(u)$	$\sigma(u)/\sigma(y)$	$\rho(u,y)$
Advanced				
Australia	1.20	9.04	7.51	−0.71
Austria	1.06	9.36	8.81	−0.33
Belgium	0.96	7.37	7.65	−0.59
Canada	1.44	8.26	5.74	−0.86
Denmark	1.30	11.21	8.61	−0.68
Finland	2.32	14.82	6.38	−0.72
Ireland	3.04	10.73	3.53	−0.52
Netherlands	1.21	10.92	9.01	−0.70
New Zealand	1.35	10.71	7.94	−0.42
Norway	1.80	14.29	7.93	−0.40
Portugal	1.46	8.35	5.72	−0.80
Spain	1.32	9.09	6.89	−0.72
Sweden	1.64	14.58	8.87	−0.48
Switzerland	1.14	15.74	13.80	−0.70
Mean	1.52	11.03	7.74	−0.62
Median	1.33	10.72	7.79	−0.69
Emerging				
Argentina	3.47	6.30	1.82	−0.62
Brazil	1.90	10.00	5.27	−0.38
Chile	1.80	10.56	5.88	−0.71
Czech Republic	1.88	12.49	6.64	−0.58
Hungary	1.40	6.44	4.59	−0.37
Israel	1.69	8.67	5.13	−0.33
Malaysia	2.14	7.36	3.44	−0.43
Mexico	3.24	12.62	3.89	−0.35
Peru	1.46	5.28	3.61	−0.34
Philippines	1.04	7.60	7.29	−0.05
Slovakia	2.29	9.34	4.07	−0.66
Slovenia	1.99	9.21	4.63	−0.69
Thailand	2.33	13.31	5.72	−0.29
Turkey	3.71	10.48	2.83	−0.78
Mean	2.17	9.26	4.63	−0.47
	[0.019]	[0.086]	[0.000]	[0.047]
Median	1.94	9.28	4.61	−0.41
	[0.008]	[0.104]	[0.000]	[0.041]

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.

2.1. Unemployment rate dynamics

We divide small open economies with sufficiently long quarterly unemployment and output data into advanced economies (AEs) and emerging market economies (EMEs), following the literature (e.g., Aguiar and Gopinath, 2007; Boz et al., 2015; Epstein et al., 2019).[3] This yields 14 AEs (Australia, Austria, Belgium, Canada, Denmark, Finland, Ireland, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, and Switzerland) and 14 EMEs (Argentina, Brazil, Chile, Czech Republic, Hungary, Israel, Malaysia, Mexico, Peru, Philippines, Slovakia, Slovenia, Thailand, and Turkey). The data are obtained from the IMF's *International Financial Statistics* (IFS) for the 1980Q1–2018Q2 sample period.[4] All data series are in real terms, seasonally adjusted using the US Census Bureau's X-12 ARIMA technique, and, after applying the natural logarithm, detrended using the HP filter with a smoothing parameter of 1600.

Table 1 provides an overview of unemployment rate patterns 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. Several differences between the two groups of countries stand out. First, output fluctuations in EMEs are more pronounced than in AEs, consistent with the related literature (e.g., Neumeyer and Perri, 2005). Second, EMEs exhibit much lower absolute and relative volatility of the unemployment rate compared to AEs. The mean (median) relative standard deviation of the unemployment rate to output is 4.63 (4.61) in EMEs and 7.74 (7.79) in AEs. The difference in group means (medians) is statistically significant with a p-value of 0.000

[3] Slight differences in country coverage are due to unemployment data availability since most of the related studies do not examine unemployment fluctuations.

[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.

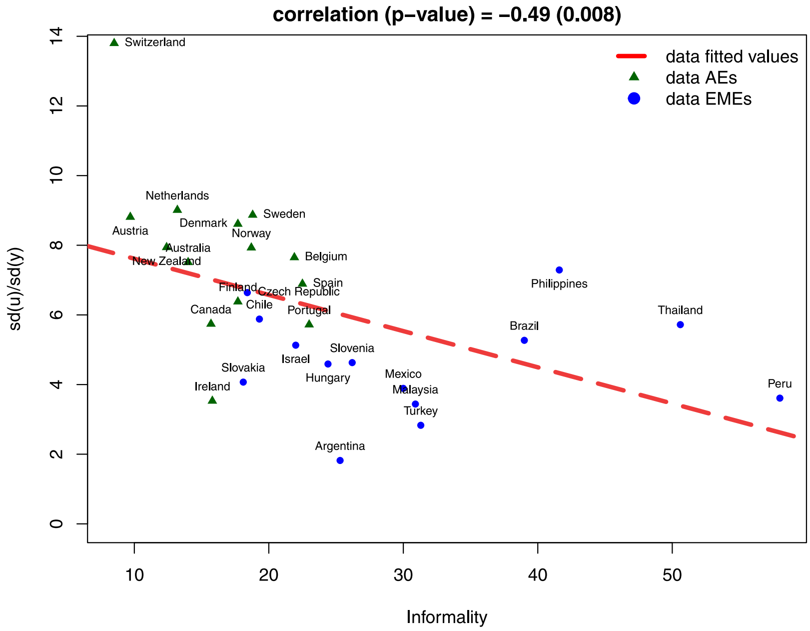

Fig. 1. Relative volatility of unemployment rate to output versus informal economy. Notes: The figure plots the relative volatility of unemployment rate to output and informality — the size of the informal economy as a percentage of GDP.

(0.000). Third, the unemployment rate tends to be less countercyclical in EMEs than in AEs. The mean (median) correlation between the unemployment rate and output is −0.47 (−0.41) in EMEs and −0.62 (−0.69) in AEs. The correlations are significantly different with a *p*-value of 0.047 for means and 0.041 for medians.[5]

2.2. Unemployment rate dynamics and informality

We hypothesize that the distinct unemployment rate dynamics between AEs and EMEs may be attributed to the size of informal economy. We define the informal economy as the market-based value added of productive legal economic activities that go unregistered by the government (Restrepo-Echavarria, 2014).[6] Using the data from Table 3.3.6 in Schneider et al. (2010), we find that the average size of informality over the 1999–2007 period in our sample of AEs is 16.4% of GDP, while in EMEs it is almost twice as large at 30.8% of GDP.[7] The informal sector plays an important role in labor market flows between unemployment and informal employment, which contributes to the explanation of unemployment rate fluctuations in a representative EME, Mexico, as highlighted in Table B.1 in Appendix B.

In Figs. 1 and 2, we further demonstrate a close link between informality and unemployment rate fluctuations in small open economies. Fig. 1 shows that the relative volatility of the unemployment rate decreases with the size of the informal economy, while Fig. 2 reveals that the unemployment rate becomes less countercyclical as the size of the informal economy increases.[8] The red dashed lines depict the fitted values from regressing the relative unemployment rate volatility, and in turn the correlation between unemployment rate and output, onto the size of the informal economy. The correlations between the plotted variables, reported above each figure, are found to be statistically significant with p-values of 0.008 (Fig. 1) and 0.007 (Fig. 2).

In the next section, we use this evidence to construct a theoretical model that accounts for the informal economy in order to examine the underlying mechanisms between the informal economy and labor market dynamics in small open economies.

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

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

[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, 2020), as self-employment (Loayza and Rigolini, 2011), or based on a dynamic general equilibrium model (Elgin and Oztunali, 2012). We prefer the measurement in Schneider et al. (2010) as it is available for all countries in our analysis.

[8] We also find a negative relationship between informality and absolute volatility of the unemployment rate.

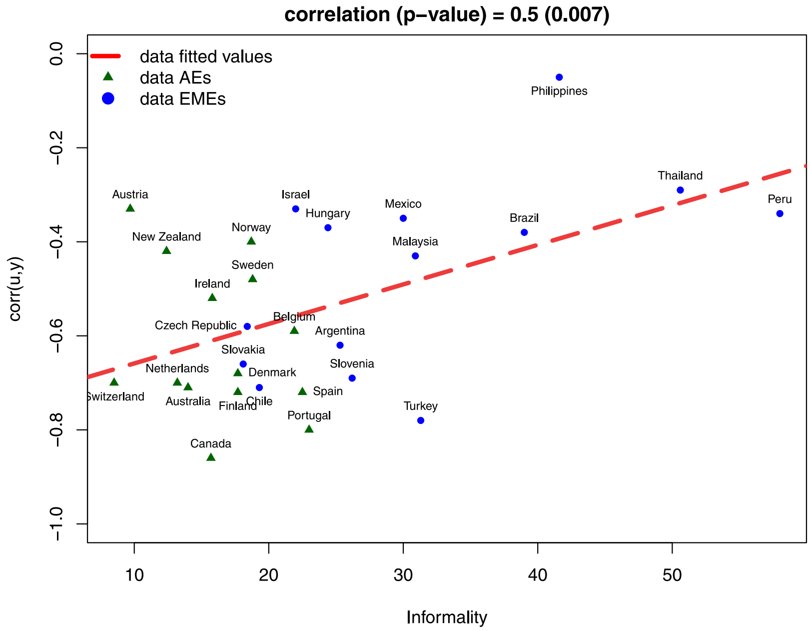

Fig. 2. Correlation between unemployment rate and output versus informal economy. Notes: The figure plots the correlation between unemployment rate and output, and informality — the size of informal economy as a percentage of GDP.

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 share consumption risk. Members can choose to work in the formal sector, informal sector, or not to work. Formal production and labor income, in contrast to informal ones, are taxed. The informal sector faces a probability of being audited and fined by the government. The sources of aggregate fluctuations in our framework are sector-specific technology shocks and country interest rate 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, a fraction of household members works in the formal sector (n_f), in the informal sector (n_i), or does not work (u). In the formal sector, firms post vacancies to attract workers for production. A matched formal worker–firm pair is dissolved with an exogenous separation rate s. Dissolved formal workers become unemployed or reallocate to the informal sector, and start searching for a formal sector job in the next period. Together, $n_f + n_i + u = 1$, implying that u also denotes the unemployment rate in the economy.

The model abstracts from the out-of-labor force margin.[9] We are motivated by the evidence presented in Fig. B.1 and Table B.1 in Appendix B. The gross labor market flows between total (formal and informal) employment and unemployment account for a considerably larger fraction of the unemployment rate variance in Mexico over the 1987–2016 period than flows between out-of-labor force and unemployment.

We assume, in line with Cano-Urbina and Gibson (2020), 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 assumption of on-the-job search by informal workers is based on the evidence presented in Table B.2 in Appendix B, where the flows between formal and informal employment, and between formal employment and unemployment, have a comparable contribution to formal employment rate fluctuations in Mexico.[10]

The measure of vacancies and searchers for formal jobs is 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 and α_m the elasticity of matching. We define the probability of filling a vacancy as $q \equiv M(u+n_i, v)/v = \omega(v/(u+n_i))^{-\alpha_m} = \omega\theta^{-\alpha_m}$, 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.

[9] See for example, Finkelstein Shapiro (2018) and Leyva and Urrutia (2020) for studies that examine the impact of the labor force participation margin on labor market dynamics in emerging economies.

[10] Section 6.4 provides sensitivity analysis by lowering the degree of flows from informal to formal employment.

3.2. Firms

Firms operate either in a formal sector f or in an informal sector i.[11] The formal labor market is subject to search-and-matching frictions, while the informal labor market is frictionless, capturing the fact that labor market frictions are much larger in the formal sector (e.g. Colombo et al., 2019; Satchi and Temple, 2009; Zenou, 2008).

3.2.1. Formal firms

Every period, formal firms employ n_f workers with each worker earning a formal wage rate w_f, and pay a tax rate τ_n on their wage bill. We denote the current value of a formal firm successfully matched with a worker as $J(n_f, x)$, while $x \equiv (z_f, z_i, r)$ represents the exogenous aggregate state with z_f denoting formal sector productivity, z_i informal sector productivity, and r country interest rate.[12] The formal firm chooses vacancies to maximize its present value of expected 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 the 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 each period is denoted by κ. y_f denotes output produced by formal firms and α_f captures formal labor share of formal output. $\rho(x,x') \equiv \beta U_{c'_f}/U_{c_f}$ represents the stochastic discount factor, with which firms discount their future profits. β is the household's subjective discount factor and U_{c_f} is 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 the firm's after-tax profit and the expected discounted value of the match continuing to the next period.

Combining the firm's two optimality conditions leads to the following job creation equation

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

Formal firms keep posting vacancies until the cost of an additional worker equals the expected discounted benefit of hiring an additional worker. The formal sector productivity, 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 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 labor share of informal output. Informal firms face an endogenous probability π_A of being audited. Once audited, a fraction ζ of their output is seized by the government. With probability $1-\pi_A$, the informal activity goes undetected. The firm pays a competitive wage rate w_i and chooses n_i to maximize its profit given by:

$$\max_{n_i}[(1-\pi_A\zeta)p_c y_i - w_i n_i], \tag{6}$$

where p_c denotes the relative price of informal to formal consumption goods. The efficiency condition requires firms each period to equate the informal wage rate to the unseized marginal product of informal output, scaled by the relative consumption price:

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

The informal sector productivity, z_i, follows a standard AR(1) process $z'_i = \rho_{zi} z_i + \epsilon'_i$, where $\epsilon_i \overset{iid}{\sim} N(0, \sigma^2_{zi})$. ρ_{zi} denotes the persistence and σ_{zi} the volatility of the informal productivity shocks.

[11] 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 the majority of informal firms consist of three or more employees (including the owner).

[12] To ease notation, we abstract from prices and transfers being functions of state variables.

3.3. Household

The infinitely-lived representative household allocates a fraction of its members to formal employment n_f, informal employment n_i, and non-working u. The household members pool resources implying that each member's consumption is equal to the household's total consumption (c_T), a composite of formal (c_f) and informal (c_i) consumption goods.

The household maximizes its expected lifetime utility represented as

$$V(n_f, d, x) = \max_{c_f, c_i, n_i, d'} \{U(c_f, c_i, n_f, n_i) + \beta E[V(n'_f, d', x')]\} \tag{8}$$

subject to the budget constraint

$$c_f + p_c c_i + (1+r)d = d' + (1-\tau_y) w_f n_f + w_i n_i + \Pi, \tag{9}$$

the law of motion of formal employment

$$n'_f = (1-s)n_f + p(u+n_i), \tag{10}$$

and the time endowment constraint

$$n_f + n_i + u = 1. \tag{11}$$

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 formal labor income, and Π captures the profit rebate from formal and informal firms. The right-hand side of Eq. (9) captures the household's total income, which can be spent on formal and informal consumption, and to pay off the last period's debt. Eq. (10) 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 the newly matched workers.

The household's optimality conditions give rise to the following equations:

$$U_{c_i} = p_c U_{c_f}, \tag{12}$$

$$U_{c_f} = \beta E[U_{c'_f}(1+r')], \tag{13}$$

$$V_{n_f}(n_f, d, x) = [(1-\tau_y)w_f - w_i]U_{c_f} + U_{n_f} - U_{n_i} + \beta(1-s-p)E[V_{n'_f}(n'_f, d', x')]. \tag{14}$$

The first optimality condition in (12) pins down the relative consumption price, which equals the marginal rate of substitution between informal and formal consumption. Eq. (13) captures the first order condition for debt holdings. Eq. (14) represents the marginal value of a matched formal sector worker, $V_{n_f}(n_f, d, x)$, which comes from the sum of the wage differential expressed in the units of 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 form

$$U(c_f, c_i, n_f, n_i) = \log(c_T) - \varphi(n)^\eta. \tag{15}$$

As in Fernández and Meza (2015) and Colombo et al. (2016), the household aggregates formal and informal consumption according to the constant elasticity of substitution (CES) aggregator:

$$c_T = [\iota(c_f)^e + (1-\iota)(c_i)^e]^{1/e}, \tag{16}$$

where $1/(1-e)$ captures the elasticity of substitution between formal and informal consumption goods, and ι denotes the share of total consumption. The total employment (n) is equal to the sum of formal and informal employment, i.e., $n = n_f + n_i$.

We set the real interest rate (r) on issued debt in world capital markets equal to the combination of a constant world interest rate ($\bar{r}$), a debt-elastic interest rate premium, and a country spread (sp) following

$$r = \bar{r} + \psi[\exp(\tilde{d} - \bar{d}) - 1] + \exp(sp - 1). \tag{17}$$

exp is the exponential function, $\psi > 0$ denotes the interest rate debt elasticity, $\bar{d}$ describes the steady state value of d, and $\tilde{d}$ represents the aggregate debt level. This setup follows, among others, Schmitt-Grohé and Uribe (2003) and Garcia-Cicco et al. (2010) in order to achieve stationarity of our small open economy model. The country spread evolves according to $\log(sp') = \rho_{sp}\log(sp) + \epsilon'_{sp}$, with $\epsilon_{sp} \overset{iid}{\sim} N(0, \sigma^2_{sp})$. We interpret the innovations in sp as country interest rate shocks.

3.4. Nash bargaining

The formal sector wage rate 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 $V_{n_f}(n_f, d, x)$. 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

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

The optimal condition for the formal wage rate yields

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

By combining Eq. (19) with the household's first order condition in (14), the free-entry condition in (5), and the marginal value of a formal worker in (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. The second one consists of the informal wage rate and the 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_y on formal labor income and τ_n on the formal wage bill. Following Aruoba (2020) and Restrepo-Echavarria (2014), the probability of auditing and catching an informal firm depends positively on the government's revenue, g, and the size of the informal sector. In particular,

$$\pi_A=gn_i^{\nu}, \tag{21}$$

where $\nu>0$ denotes surveillance intensity. Once audited, the government levies a penalty tax of $\zeta\in(0,1)$ on informal output. Hence, the government receives $\pi_A\zeta p_c y_i$ from surveillance of the informal sector. Each period, the government balances its budget given by

$$g=\tau_n w_f n_f+\tau_y w_f n_f+\pi_A\zeta p_c y_i. \tag{22}$$

3.6. Market clearing

Formal and informal goods markets clear each period

$$(1-\pi_A\zeta)y_i=c_i, \tag{23}$$

$$y_f=c_f+g+nx+\kappa v, \tag{24}$$

where net exports, nx, is equal to

$$nx=(1+r)d-d'. \tag{25}$$

Formal output covers formal consumption, government expenditures, net exports, and vacancy posting costs. As in Fernández and Meza (2015) and Restrepo-Echavarria (2014), we assume 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 find that informal employment accounts for most of the employment in the non-tradable sectors in Latin America and the Caribbean.

3.7. Equilibrium

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 Eq. (2), the government balances its budget, and all markets clear. This yields the following 12 equations and 12 endogenous variables $\{q,w_f,w_i,\theta,v,u,n_f,n_i,c_f,c_i,d',\pi_A\}$:

$$U_{c_f}=\beta E[U_{c'_f}(1+r')] \tag{26}$$

$$n_f+n_i+u=1 \tag{27}$$

$$n'_f=(1-s)n_f+qv \tag{28}$$

$$q=\omega\theta^{-\alpha_m} \tag{29}$$

$$\theta=\frac{v}{u+n_i} \tag{30}$$

$$w_i=\frac{U_{c_i}}{U_{c_f}}\alpha_i z_i(n_i)^{\alpha_i-1} \tag{31}$$

$$w_i=-\frac{U_{n_i}}{U_{c_f}} \tag{32}$$

Table 2
Parameter calibration.

Parameter	Description	Value
β	Subjective discount factor	0.97
$1/(\eta-1)$	Frisch elasticity of labor supply	0.33
φ	Disutility of labor	0.21
$1/(1-e)$	Elasticity of substitution between c_f and c_i	8
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	0.7
ζ	Penalty when caught as informal firm	0.5
ν	Surveillance intensity of informal sector	1
ρ_{zf}	Persistence of formal technology process	0.78
σ_{zf}	Volatility of formal technology process	1.168%
ρ_{zi}	Persistence of informal technology process	0.78
σ_{zi}	Volatility of informal technology process	1.168%
ρ_{sp}	Persistence of country spread process	0.97
σ_{sp}	Volatility of country spread process	0.770%

$$w_f = \frac{\alpha_b}{1+\tau_n}(\alpha_f (n_f)^{\alpha_f - 1} + \kappa\theta) + \frac{1-\alpha_b}{1-\tau_y}(w_i - \frac{U_{n_f} - U_{n_i}}{U_{c_f}}) \tag{33}$$

$$z_f (n_f)^{\alpha_f} = c_f + (1+r)d - d' + \kappa v + \tau_y w_f n_f + \tau_n w_f n_f + \pi_A \zeta \frac{U_{c_i}}{U_{c_f}} z_i {n_i}^{\alpha_i} \tag{34}$$

$$\pi_A = (\tau_n w_f n_f + \tau_y w_f n_f + \pi_A \zeta \frac{U_{c_i}}{U_{c_f}} z_i {n_i}^{\alpha_i}) n_i^{\nu} \tag{35}$$

$$z_i (n_i)^{\alpha_i} = c_i \tag{36}$$

$$\frac{\kappa}{q} = \beta E \left\{ \frac{U_{c'_f}}{U_{c_f}} [\alpha_f (z'_f)(n'_f)^{\alpha_f - 1} - (1+\tau_n) w'_f + (1-s)\frac{\kappa}{q'}] \right\}. \tag{37}$$

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 data for a representative emerging market economy, Mexico.

Table 2 presents the parameter calibration. The value assigned to the subjective discount factor, β, implies an average country interest rate of 2.7%, computed using the Emerging Market Bond Index (EMBI) spread data.[13] We fix η at 4, implying a Frisch elasticity of 0.33, which is an intermediate value of the range of estimates documented by Keane and Rogerson (2012). It also lies in the range of values used by other related studies for Mexico (e.g. Boz et al., 2015; Finkelstein Shapiro, 2018).[14] The elasticity of substitution between formal and informal consumption goods, $1/(1-e)$, is set to a standard value of 8, as adopted by Fernández and Meza (2015), Horvath (2018), Leyva and Urrutia (2020).

We calibrate the values for the disutility of employment, φ, and the share of formal consumption, ι, by using the equilibrium conditions for formal wage, informal wage, and job creation. To do so, we use the steady state values of consumption, output, and employment for each sector in Mexico over 1987Q1–2018Q2.

We set the formal labor market separation rate, s, to 0.06, and the job finding rate, q, to 0.7, in line with the estimated values for Mexico documented by Bosch and Maloney (2008) and employed by Boz et al. (2015). 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. The tax rates on the formal wage bill τ_n and on the formal labor income τ_y are equal to 0.11 and 0.07, which are the corresponding estimates for the Mexican economy by Fernández and Meza (2015).

The steady state unemployment rate, $\bar{u}$, equals 3.84%, i.e., the average unemployment rate in Mexico from 1987Q1 to 2018Q2. The implied steady state fraction of employed workers, $(1-\bar{u})$, is allocated to formal and informal employment based on the size of

[13] The data are sourced from Global Financial Data and are over the 1998Q1–2018Q4 period.

[14] Section 6.4 presents sensitivity results for η, and several other parameters chosen externally to document the robustness of main results.

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

Moment	Data	Baseline
$\sigma(y)$	3.24	3.24†
$\sigma(c)/\sigma(y)$	1.18	1.12
$\sigma(u)/\sigma(y)$	3.89	3.95
$\sigma(n)/\sigma(y)$	0.29	0.16
$\rho(c,y)$	0.94	0.94
$\rho(u,y)$	−0.35	−0.49
$\rho(n,y)$	0.37	0.49
$\rho(nxy,y)$	−0.28	−0.21

Notes: The table reports business cycle moments for Mexico. $\sigma(x)$ refers to a standard deviation of variable x. $\rho(x,z)$ refers to a correlation between x and z. The 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, u, n, nx denote y_f, c_f, u, n, nx in the model. nxy represents the trade balance-to-output ratio. † denotes targeted moments.

the informal sector.[15] As in Fernández and Meza (2015) and Leyva and Urrutia (2020), we define informality (the informal sector size) in the model as the share of informal employment out of total employment, i.e., informality $\equiv \frac{\bar{n}_i}{\bar{n}}$. We set it to 0.3, which approximates the informality for Mexico in Schneider et al. (2010). This value is lower than the values reported by Fernández and Meza (2015) and Leyva and Urrutia (2020). However, Schneider et al. (2010) provide data for other small open economies in our sample, which allows us to conduct our cross-country analysis in Section 5.2. Our informality value leads to a steady state informal employment, $\bar{n}_i$, of 0.289 (= informality$\times(1-\bar{u})$) and a steady state formal employment, $\bar{n}_f$, of 0.673 ($= 1-\bar{u}-\bar{n}_i$). The calibration approach of formal and informal employment being tied to the unemployment rate is similar to Ulyssea (2010).

We follow Andolfatto (1996) and Boz et al. (2015) by using a standard value of 0.01 for the total vacancy posting cost, $\bar{v}\kappa$. This together with the steady state formal employment value, leads to steady state vacancies, $\bar{v}$, of 0.058. It implies a unit cost of posting a vacancy, κ, of 0.173, and a 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) in Garcia-Cicco et al. (2010). We estimate the country spread process parameters using the EMBI data over the 1998Q1–2018Q4 period, as in Uribe and Yue (2006). This delivers $\rho_{sp} = 0.97$ and $\sigma_{sp} = 0.770\%$.

The remaining parameters pertain to the production functions. The labor share of output in the formal sector, α_f, is chosen to be 0.65, and in the informal sector, α_i, to be 0.7, reflecting that the informal sector is usually more labor intensive (Colombo et al., 2016). Due to the lack of empirical evidence, we set $\nu = 1$ and $\zeta = 0.5$, and document the robustness of our results to alternative values of these parameters in Section 6.4. In line with Chen et al. (2018), we assume that sector-specific 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.[16] We calibrate the persistence and the standard deviation of the technology processes such that the model replicates the observed autocorrelation and volatility of Mexican output during our sample period. This yields values of $\rho_{zf} = \rho_{zi} = 0.78$ and $\sigma_{zf} = \sigma_{zi} = 1.168\%$.[17]

5. Results

This section compares the model-generated moments with data, focusing on unemployment rate fluctuations. We first examine the case of Mexico. Then, we vary the size of the informal sector to contrast the model-generated relative volatility and countercyclicality of the unemployment rate with their cross-country data counterparts. Lastly, we examine the model mechanism through the impulse responses of model variables to productivity and interest rate shocks.

5.1. Business cycle moments in Mexico

Table 3 shows that the baseline model successfully reproduces several business cycle moments of the Mexican economy, including features of EMEs that are typically difficult to generate. The first column presents the empirical moments.[18] The second column reports the model-generated moments for the baseline case. We assume that none of the informal activity is captured in national accounts, and hence, y and c in the table denote y_f and c_f in the model.[19]

[15] 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 (2020) and Quintin (2008) for potential causes of informality.

[16] In Section 6.3, we explore the importance of the correlation and symmetry of the technology processes for our main results.

[17] Our calibrated values are in line with Boz et al. (2011) and Kemme and Koleyni (2017), among other studies focused on Mexico.

[18] Due to the lack of data availability, we do not report vacancy-related moments.

[19] We consider the role of measurement of informality in the national statistics in Section 6.

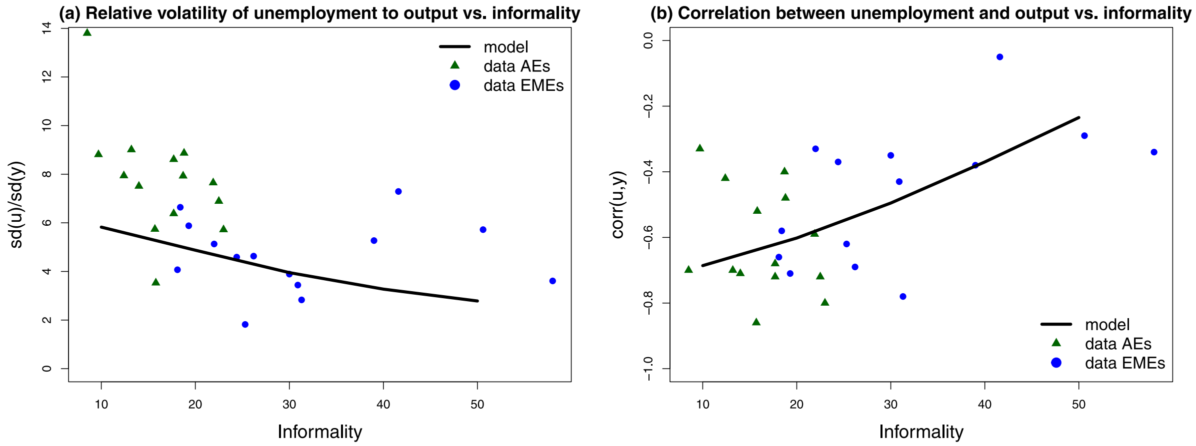

Fig. 3. Unemployment dynamics and informality: Data versus model. Notes: Panel (a) on the left plots the relative volatility of the unemployment rate to output versus informality. Panel (b) on the right plots the correlation between unemployment rate and output versus informality. The solid black line denotes model-generated values.

It can be seen from Table 3 that our model captures well the relative unemployment rate volatility (3.95 compared to 3.89 in the data), and the unemployment rate countercyclicality (correlation coefficient of −0.49 compared to −0.35 in the data). In addition, the model delivers a more volatile consumption than output and total employment that displays low volatility and cyclicality, in line with data. The behavior of total employment is driven by volatile and countercyclical informal employment, which offsets the procyclicality of formal employment, as documented for Mexico by Fernández and Meza (2015). As a result, our baseline model produces a strongly countercyclical informality rate (n^i/n), consistent with the findings of Leyva and Urrutia (2020). Lastly, the model generates the observed countercyclicality of the trade balance-to-output ratio, another salient business cycle feature of EMEs.

5.2. *Informal economy and unemployment dynamics*

How does the size of the informal sector impact unemployment rate fluctuations across small open economies? To address this question, we vary the size of informality in the model from 0.1 to 0.5. In particular, the steady state values of informal and formal employment change according to $\bar{n}_i = \text{informality}\times(1-\bar{u})$ and $\bar{n}_f = 1-\bar{u}-\bar{n}_i$, while the steady state value of the unemployment rate ($\bar{u}$) remains unchanged.[20]

We report the results in Fig. 3. The solid black line graphs the simulation results from the model. The triangles and dots represent the data points for AEs and EMEs from Figs. 1 and 2. Overall, Fig. 3 shows that the size of the informal sector plays an important role in driving the cross-country differences in unemployment rate behavior.

Panel (a) in Fig. 3 reveals that the baseline model generates a strong negative relationship between the size of the informal sector and the relative volatility of the unemployment rate to output. The relative volatility ranges from 5.82 (10% informality) to 2.78 (50% informality). Panel (b) in Fig. 3 highlights that the model simultaneously reproduces the positive relationship between unemployment rate cyclicality and informality: the larger the informal sector, the less countercyclical the unemployment rate. The correlation between the unemployment rate and output extends from −0.68 (10% informality) to −0.23 (50% informality).

5.3. *Mechanism*

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

5.3.1. *Formal productivity shocks*

Fig. 4 presents the impulse response functions, expressed in percentage deviations from the steady state, to a one percent increase in *formal* productivity. The blue solid line represents the baseline model responses when informality equals 0.3. Formal output, consumption, and employment increase in response to the shock, as formal firms increase vacancy postings and the household substitutes formal for informal consumption. However, search friction prevents an immediate adjustment of formal employment. Together with the initial drop in informal employment, unemployment increases on impact. After the initial period,

[20] The model parameters that depend on $\bar{n}_i$ and $\bar{n}_f$, are recalibrated accordingly.

formal employment gradually increases as informal sector workers and unemployed members reallocate to the formal sector in order to take advantage of higher formal sector productivity. This, in turn, lowers the unemployment rate. The household's 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 the informal sector plays a key role in propagating shocks throughout the economy. Fig. 4 compares the baseline economy with 30% of total employment being informal (solid line) to an economy with informality of 15% (dashed line). A smaller informal sector leads to a larger decrease in unemployment and a smaller increase in formal output. A lower informality implies a smaller pool of informal workers for reallocation to the formal sector, forcing the household to depend more on unemployed members when responding to the productivity increase. This is reflected in a larger drop in informal employment and in a less pronounced increase in 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.

5.3.2. Informal productivity shocks

Fig. 5 shows the impulse responses to a one percent increase in *informal* productivity. The temporarily higher informal productivity incentivizes the household to substitute from formal to informal consumption, and to reallocate unemployed members to the informal sector. This raises informal employment, consumption, and output, and decreases formal consumption. The responses of formal and informal consumption raise the stochastic discount factor, which increases the expected continuation value of a formal match, and hence makes vacancy postings more profitable — a link highlighted by the job creation condition in Eq. (5). The resultant increase in vacancy postings gradually stimulates formal employment and output.[21]

Similarly to Fig. 4, Fig. 5 shows that the size of the informal sector dictates the strength of shock propagation. The responses of formal output, consumption, and employment become more pronounced when informality doubles from 15 to 30 percent. The responses of informal sector variables, however, become less pronounced due to the diminishing returns to production as the pool of informal workers expands. The unemployment rate's response remains largely unchanged. The reason involves two offsetting forces. A more sizable informal sector leads to a smaller 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 largely cancel out, implying a very similar unemployment response. All in all, relative unemployment rate volatility and countercyclicality both decrease with informality because of the relatively larger increase in output.

5.3.3. Interest rate shocks

Fig. 6 describes impulse responses to a one percent interest rate increase. According to the job creation condition in Eq. (5), a higher interest rate increases the rate at which formal firms discount their expected future profits.[22] Lower expected profits decrease the firms' vacancy postings and translate to a reduction in formal employment, output, and consumption. Given the substitutability between formal and informal consumption, the household increases informal consumption and output by reallocating its members to the informal sector.

Because of labor market frictions in the formal sector, the increase of informal employment lowers the unemployment rate on impact. However, the adjustment of formal employment in the following periods gradually raises the unemployment rate. As the interest rate shock subsides, formal firms increase their vacancy postings, as their expected future profits increase. This, in turn, generates a small expansion of the formal sector, at the expense of decreasing informal sector quantities. Overall, the adverse impact of interest rate shocks on formal quantities and unemployment is consistent with the evidence provided by Akıncı (2013) and Epstein et al. (2019).

Similarly to productivity shocks, the size of the informal sector amplifies the transmission of interest rate shock. A lower informality leaves the household with a smaller pool of informal workers for labor adjustment, leading to a weaker response of formal quantities and a stronger response of informal quantities. As the shock recedes, the smaller informal sector also brings about a sharper reduction in informal employment. This implies a more pronounced increase in unemployment, and a less pronounced increase in formal consumption and output, about 10 quarters after the shock. In summary, the unemployment rate becomes more volatile and countercyclical with smaller informality, in line with evidence presented in Figs. 1 and 2.

6. Extensions

In this section, we extend our baseline model to examine the role of (mis)measurement of workers and output, informal features, and exogenous shocks on our main results. Lastly, we conduct sensitivity analysis of several model parameters.

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

22 The disproportional impact of interest rate shock on formal firms is analogous to the mechanism presented in Leyva and Urrutia (2020).

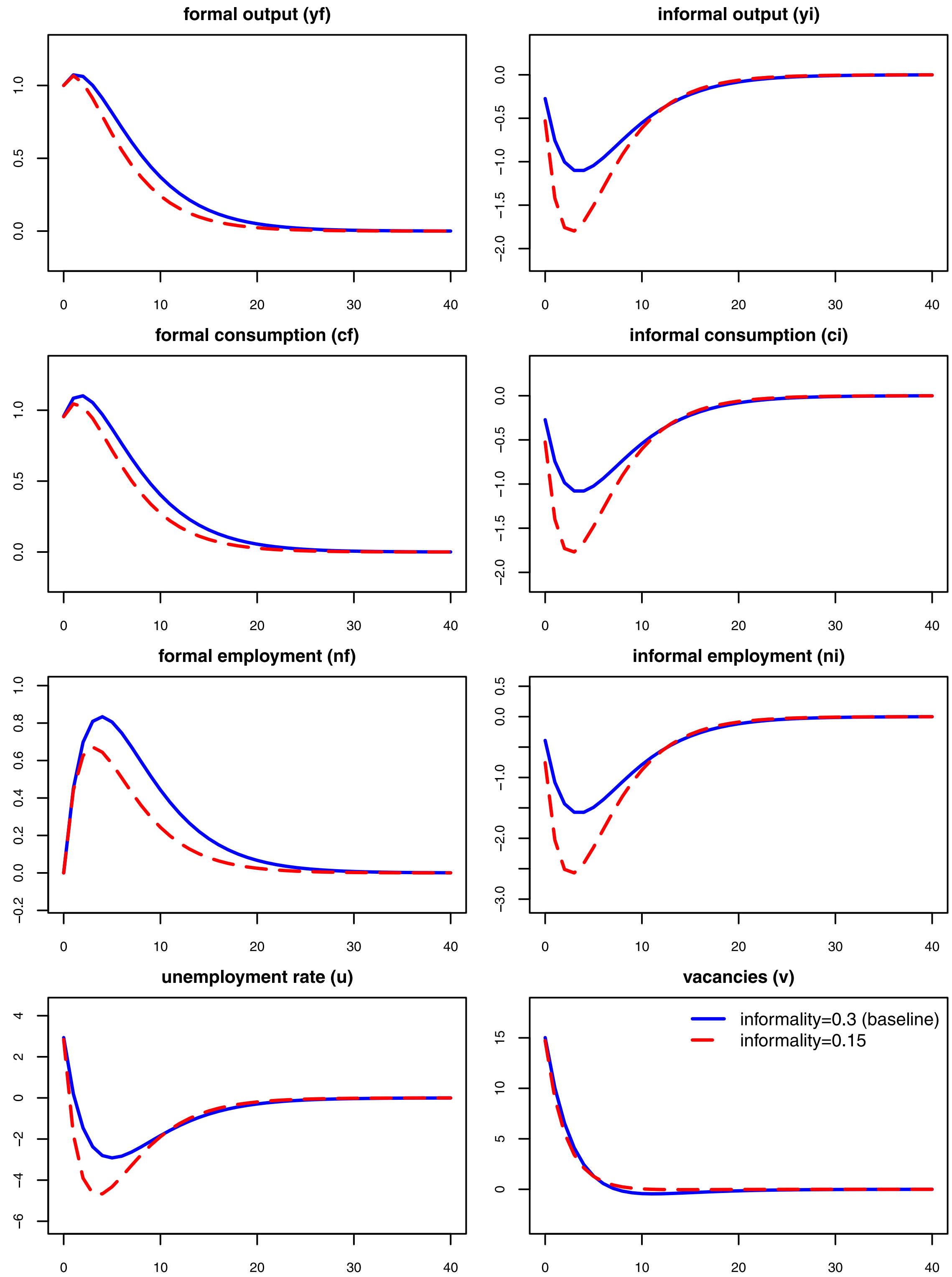

Fig. 4. Impulse responses to a positive formal productivity shock. Notes: The figure plots the impulse response functions of formal and informal output, consumption, employment, unemployment rate, and vacancies to a one percent increase in formal productivity. The solid line denotes the baseline model with an informal employment share of 0.3 of total employment. The dashed line denotes a model with an informal employment share of 0.15 of total employment.

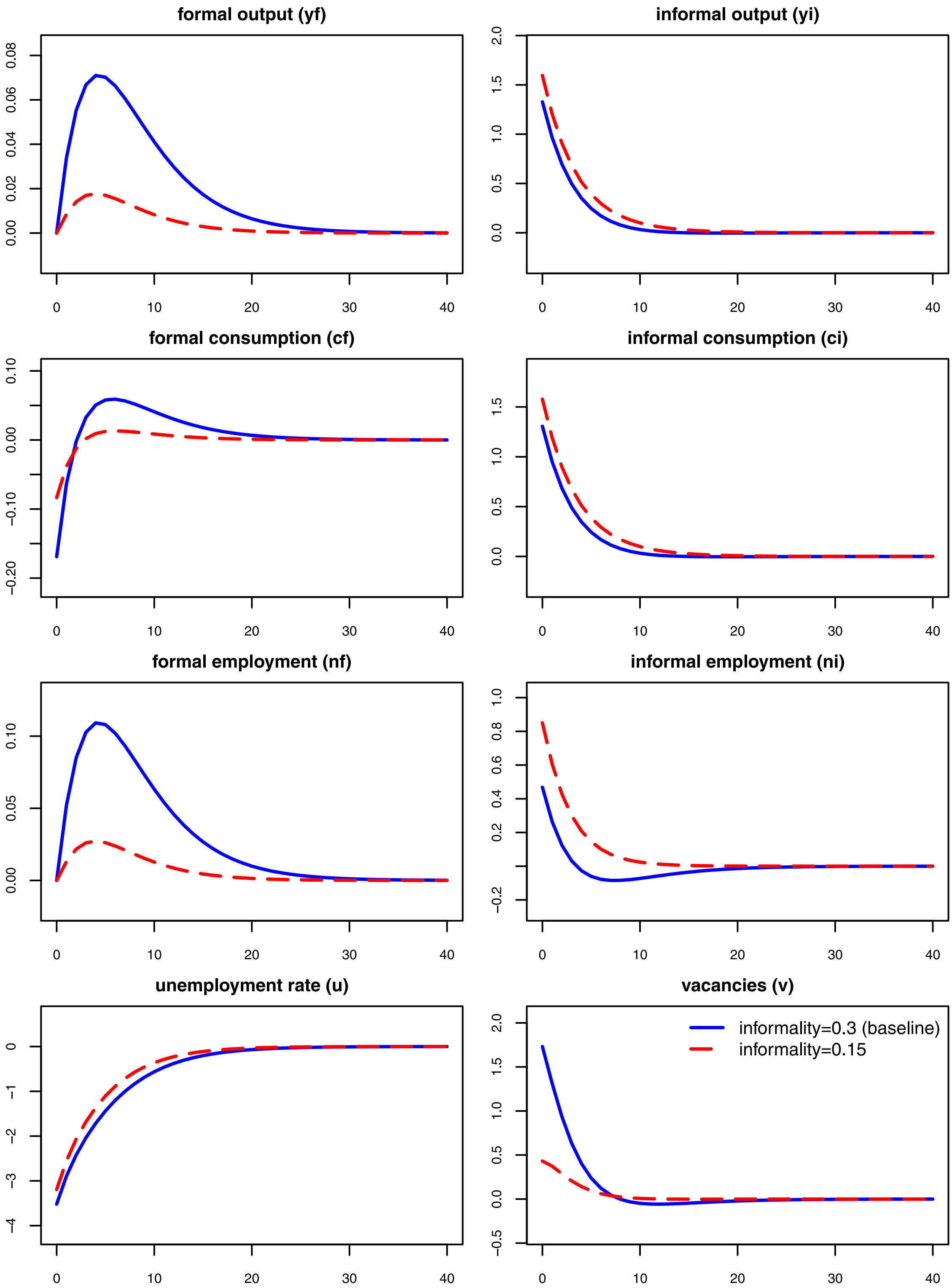

Fig. 5. Impulse responses to a positive informal productivity shock. Notes: The figure plots the impulse response functions of formal and informal output, consumption, employment, unemployment rate, and vacancies to a one percent increase in informal productivity. The solid line denotes the baseline model with an informal employment share of 0.3 of total employment. The dashed line denotes a model with an informal employment share of 0.15 of total employment.

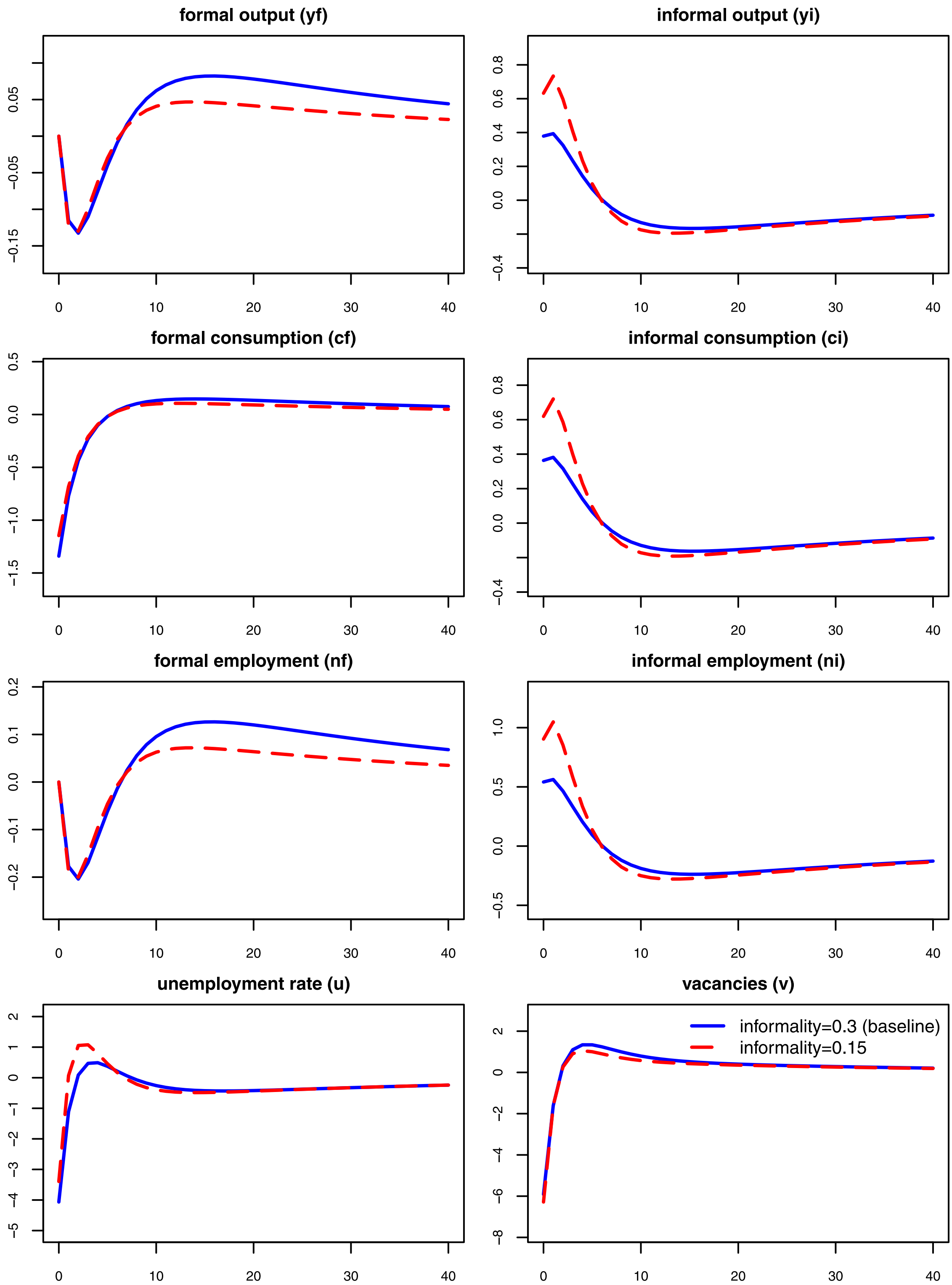

Fig. 6. Impulse responses to a positive interest rate shock. Notes: The figure plots the impulse response functions of formal and informal output, consumption, employment, unemployment rate, and vacancies to a one percent increase in the interest rate. The solid line denotes the baseline model with an informal employment share of 0.3 of total employment. The dashed line denotes a model with an informal employment share of 0.15 of total employment.

Table 4
Business cycle moments in Mexico: The role of mismeasurement.

Moment	(1) Baseline	(2) u_{IMi}	(3) u_{IMf}	(4) y_{IM}
$\sigma(y)$	3.24	3.24	3.24	2.58
$\sigma(c)/\sigma(y)$	1.12	1.12	1.12	1.03
$\sigma(u)/\sigma(y)$	3.95	3.14	5.83	4.97
$\sigma(n)/\sigma(y)$	0.16	0.16	0.16	0.20
$\rho(c,y)$	0.94	0.94	0.94	0.93
$\rho(u,y)$	−0.49	−0.58	−0.38	−0.51
$\rho(n,y)$	0.49	0.58	0.38	0.51
$\rho(nxy,y)$	−0.21	−0.21	−0.21	−0.19

Notes: The table reports 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. nxy denotes the trade balance-to-output ratio. '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, u, n, nx denote y_f, c_f, u, n, nx in the model. '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) are double-counted; they are included in both informal and formal employment, i.e., unemployment is measured as $u_{IMf} = 1 - n_f - (1+0.05)n_i$. '$y_{IM}$' considers a scenario when the contribution of the observed informal activities to total output is 12% and unemployment is measured perfectly, i.e., y, c, n, u, nx denote $y_{IM}, c_{IM}, n, u, nx_{IM}$ in the model.

6.1. The role of mismeasurement

Many countries employ various approaches to infer the extent of informal activities (see, e.g., Horvath, 2018; Restrepo-Echavarria, 2014). In Table 4, we compare our baseline results with three types of mismeasurement: misattributing informal workers to unemployment, misattributing informal workers to formal employment, and partially accounting for informal sector activities.

First, we consider the possibility that informal workers may under-report their employment. Column 2 (u_{IMi}) presents the results of attributing 5% of informal workers to unemployment.[23] 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, in which case a worker may be counted in both formal and informal employment, inflating the total labor force. Column 3 (u_{IMf}) considers a case of counting 5% of informal 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 the unemployment rate to output decreases and the countercyclicality of the unemployment rate 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.

Fernández and Meza (2015) provide evidence that, based on the Mexican statistical agency INEGI, the contribution of the observed informal activities to total output was about 12% over the 1998–2003 period. To allow for this possibility, we define imperfectly measured output, consumption, and net exports each period as follows:

$$y_{IM} = y_f + \phi p_c y_i, \tag{38}$$

$$c_{IM} = c_f + \phi p_c c_i, \tag{39}$$

$$nx_{IM} = y_{IM} - c_{IM} - g - \kappa v, \tag{40}$$

where ϕ captures the fraction of informal sector included in the national accounts. To be in line with the empirical evidence, we calibrate ϕ using the following equation

$$\Omega = \frac{\phi \bar{p}_c \bar{y}_i}{\bar{y}_f + \phi \bar{p}_c \bar{y}_i}, \tag{41}$$

where $\Omega = 0.12$, as reported by Fernández and Meza (2015). This implies that ϕ is calibrated in our setup to be 0.52, i.e., about a half of the informal sector is captured by the government.

Column 4 shows that the volatility of output decreases with improved measurement of the informal sector. Informal output is negatively correlated with formal output, due to the substitutability between formal and informal consumption goods. Given that the measured output incorporates a fraction of informal activities in addition to formal ones, its volatility decreases. This points

[23] We chose 5% for illustration purposes due to lack of empirical evidence.

Table 5
Business cycle moments in Mexico: The role of informal features.

Moment	(1) Baseline	(2) $\zeta = 0.9$	(3) $\nu = 1.5$	(4) $\alpha_i = 0.65$	(5) $\frac{\bar{n}_i}{\bar{n}} = 0.16$
$\sigma(y)$	3.24	3.29	3.24	3.23	2.90
$\sigma(c)/\sigma(y)$	1.12	1.13	1.12	1.12	1.10
$\sigma(u)/\sigma(y)$	3.95	4.01	3.97	4.18	5.29
$\sigma(n)/\sigma(y)$	0.16	0.16	0.16	0.17	0.21
$\rho(c,y)$	0.94	0.94	0.94	0.94	0.94
$\rho(u,y)$	−0.49	−0.52	−0.49	−0.55	−0.64
$\rho(n,y)$	0.49	0.52	0.49	0.55	0.64
$\rho(nxy,y)$	−0.21	−0.18	−0.22	−0.18	−0.23

Notes: The table reports 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. y, c, u, n, nx denote y_f, c_f, u, n, nx in the model. 'Baseline' refers to the baseline model where the calibration sets the amount of fine when caught operating informal technology $\zeta = 0.5$, surveillance intensity $\nu = 1$, informal labor share $\alpha_i = 0.7$, and informality $\frac{\bar{n}_i}{\bar{n}} = 0.3$.

to an additional explanation of 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, capturing a larger share of it. Due to lower output volatility, the relative volatility and countercyclicality of unemployment both increase. The relative volatility of consumption decreases as well with improvements in measuring the informal sector, as in Restrepo-Echavarria (2014). In our framework, it becomes close to one when roughly half of the informal sector is accounted for, highlighting another difference in the business cycle behavior between AEs and EMEs (see, e.g., Neumeyer and Perri, 2005; Aguiar and Gopinath, 2007).

Overall, these findings complement the results in Fig. 3 and show that not only the size of the informal sector but also its mismeasurement plays an important role for the unemployment rate dynamics in small open economies.

6.2. The role of informal features

In this section, we explore the role of several institutional features pertinent to the informal sector in driving business cycle fluctuations. We report the results in Table 5 and compare them to the baseline model moments listed in column 1.

We first consider the role of the fine (penalty tax) paid by informal firms when they are caught by the government, ζ. Column 2 increases ζ from a baseline value of 0.5 to 0.9, i.e., informal firms have to forego 90% of their output once audited. A higher penalty reduces the expected marginal revenue for informal firms based on Eq. (7), decreasing informal labor demand, and hence, all else equal, informal activity. This slightly increases the relative volatility of the unemployment rate and its countercyclicality, changing the moments in the direction of the ones observed in AEs. However, the effect is small as informal firms face a relatively low probability of being audited on average.

In column 3, we raise the parameter governing the surveillance intensity of informal activities ν to 1.5 from the baseline value of 1. According to Eq. (21), a higher ν reduces the informal firm's probability of getting caught since the steady state value of n_i is less than one. Column (3), however, shows that the change in ν does not significantly affect business cycle dynamics, in line with the findings in Restrepo-Echavarria (2014).

In the baseline model, we set the labor share of output in the informal sector α_i to 0.7, motivated by the evidence that the informal sector is typically more labor intensive than the formal sector. In column 4, we instead consider the same labor share in both sectors, i.e., we reduce α_i to 0.65. A smaller labor share of informal output decreases the marginal product in the informal sector, as shown by Eq. (7), and hence decreases incentives to work in the informal sector. A lower α_i weakens the link between informal employment and informal output fluctuations, implying less substitution between formal and informal labor. This strengthens the role of unemployment in absorbing shocks. As a result, the model generated labor market dynamics move closer to the characteristics of AEs, as both the relative volatility and countercyclicality of the unemployment rate increase.

Lastly, in column 5, we directly reduce the size of informality $\frac{\bar{n}_i}{\bar{n}}$ by nearly half, from the baseline value of 0.3 (as in EMEs) to 0.16, which is the informality rate observed in a typical AE in our sample. A smaller informal sector translates into a weaker substitution between formal and informal employment, dampening fluctuations in formal output and consumption, while amplifying fluctuations in the unemployment rate. The model generated relative volatility of the unemployment rate increases from 3.95 to 5.29, and the countercyclicality of the unemployment rate increases (in magnitude) from −0.49 to −0.64. This compares well with the data, where the median values for the relative volatility and countercyclicality of the unemployment rate for EMEs (AEs) are 4.61 (7.79) and −0.41 (−0.69), as reported in Table 1. As also shown in Fig. 3 in Section 5.2, the features of the labor market in this case resemble more closely the ones in AEs, with larger relative volatility and countercyclicality of the unemployment rate. Moreover, the model produces a lower output and consumption volatility, additional distinct patterns observed in AEs.

Table 6
Business cycle moments in Mexico: The role of shocks.

Moment	(1) Baseline	(2) $z_f = z_i$	(3) $\rho(z_f, z_i) = 0.5$	(4) No z_f shocks	(5) No z_i shocks	(6) No r shocks
$\sigma(y)$	3.24	3.43	3.67	0.39	3.23	3.22
$\sigma(c)/\sigma(y)$	1.12	1.07	1.07	3.57	1.12	1.04
$\sigma(u)/\sigma(y)$	3.95	4.28	4.18	9.66	3.23	3.80
$\sigma(n)/\sigma(y)$	0.16	0.17	0.17	0.36	0.13	0.15
$\rho(c, y)$	0.94	0.94	0.95	0.59	0.94	1.00
$\rho(u, y)$	−0.49	−0.90	−0.81	−0.43	−0.57	−0.50
$\rho(n, y)$	0.49	0.90	0.81	0.43	0.57	0.50
$\rho(nxy, y)$	−0.21	−0.24	−0.24	−0.41	−0.20	−0.71

Notes: The table reports 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. y, c, u, n, nx denote y_f, c_f, u, n, nx in the model. 'Baseline' refers to the baseline model with uncorrelated formal and informal productivity shocks. '$z_f = z_i$' denotes a model with a common productivity shock in the formal and informal sectors. '$\rho(z_f, z_i) = 0.5$' stands for a model with formal and informal productivity shocks, which have a correlation of 0.5. 'No z_f shocks', 'No z_i shocks', and 'No r shocks' denote models with no formal productivity shocks, no informal productivity shocks, and no interest rate shocks.

6.3. The role of shocks

In this section, we explore the role of sector-specific uncorrelated productivity shocks and interest rate shocks for the model generated second moments in Mexico. Table 6 reports the findings and shows that formal productivity shocks are central to unemployment rate fluctuations.

For comparison, column 1 in Table 6 reproduces the results of the baseline model. In column 2, we consider a common productivity process for both (formal and informal) sectors. The two sectors attract unemployed workers simultaneously in response to increases in productivity, leading to a larger volatility and countercyclicality of the unemployment rate. By reducing sectoral productivity differentials, the common shock process decreases the relative volatility of consumption.

In column 3, we increase the correlation of the sector-specific technology shocks from 0 (baseline) to 0.5. Similar to the common productivity shock case, the relative volatility of consumption somewhat decreases, while the relative volatility and countercyclicality of the unemployment rate increase compared to the baseline case. The increase is smaller as the shocks are not perfectly correlated.

In columns 4 through 6, we shut down one shock at a time. Eliminating formal productivity shocks in column 4 leads to a large reduction in output volatility, because none of the informal sector output is assumed to be included in the measured output. However, through the substitution between formal and informal consumption goods, informal sector fluctuations still perturb formal consumption and unemployment dynamics, leading to a large increase in their relative volatility levels.

In column 5, we shut down the fluctuations in informal productivity. This increases the contribution of formal productivity shocks to labor market dynamics, making the unemployment rate marginally less volatile and more countercyclical.

In column 6, we eliminate interest rate shocks. Compared to the baseline results, interest rate shocks help with increasing the relative volatility of consumption and reducing consumption procyclicality. They also reduce the countercyclicality of the trade balance-to-output ratio. Unemployment rate dynamics, however, remain largely unaffected.

6.4. Sensitivity analysis

This section documents the robustness of our baseline results by varying values of several parameters that we adopt from literature.

We report the first set of results in Table 7. In column 2 we lower the elasticity of substitution between formal and informal consumption, $\frac{1}{1-e}$, to 5 from the benchmark value of 8. The lower value is usually considered for the elasticity between market and non-market consumption goods in the home production literature (e.g. Benhabib et al., 1991; Chen et al., 2018). A household with a lower elasticity is less willing to substitute between formal and informal consumption when the relative price of consumption changes, which reduces the relative volatility of consumption. The lower substitutability also reduces the role of the informal sector in absorbing shocks from the formal sector, and therefore results in a higher volatility and countercyclicality of unemployment.

Column 3 in Table 7 examines the impact of a higher labor supply elasticity. In particular, we increase the Frisch elasticity, $\frac{1}{\eta-1}$, from the baseline value of 0.33 to 0.5, which is the upper bound estimate in the preferred model of Cacciatore et al. (2020). The higher Frisch elasticity raises the responsiveness of the total labor supply, which increases the fluctuations in unemployment and consumption, and decreases the variability of output and its comovement with unemployment.

In column 4, we lower the vacancy posting cost, κ, to 0.1, a value considered in Boz et al. (2015), from our baseline value of 0.173. We find that output and unemployment volatility increase as firms are more willing to adjust their vacancies in response to shocks due to lower posting costs and a shorter employment duration. The more frequent vacancy adjustment translates to a more volatile labor market. In turn, the volatility and countercyclicality of unemployment rise.

Table 7
Business cycle moments in Mexico: Sensitivity analysis.

Moment	(1) Baseline	(2) $\frac{1}{1-e}=5$	(3) $\frac{1}{\eta-1}=0.5$	(4) $\kappa=0.1$	(5) $\xi=0.727$
$\sigma(y)$	3.24	3.30	2.96	3.68	3.21
$\sigma(c)/\sigma(y)$	1.12	1.10	1.22	1.11	1.13
$\sigma(u)/\sigma(y)$	3.95	4.27	4.54	4.22	3.94
$\sigma(n)/\sigma(y)$	0.16	0.17	0.18	0.17	0.16
$\rho(c,y)$	0.94	0.94	0.94	0.95	0.94
$\rho(u,y)$	−0.49	−0.62	−0.28	−0.66	−0.35
$\rho(n,y)$	0.49	0.62	0.28	0.66	0.35
$\rho(nxy,y)$	−0.21	−0.21	−0.33	−0.24	−0.20

Notes: The 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,u,n,nx denote y_f,c_f,u,n,nx in the model. ξ restricts the flow of informal workers to the formal sector in the law of motion for formal employment as $n'_f=(1-s)n_f+p(u+\xi n_i)$. The baseline model calibration sets $1/(1-e)=8$, $1/(\eta-1)=0.33$, $\kappa=0.173$, and $\xi=1$.

Table 8
Business cycle moments in Mexico: Closing the model.

Moment	(1) Baseline	(2) $\psi=7$	(3) $\psi=0.07$	(4) DAC	(5) DAC recalib.
$\sigma(y)$	3.24	3.21	4.67	3.41	3.24
$\sigma(c)/\sigma(y)$	1.12	1.06	1.87	1.31	1.34
$\sigma(u)/\sigma(y)$	3.95	3.80	5.15	4.29	4.34
$\sigma(n)/\sigma(y)$	0.16	0.15	0.21	0.17	0.17
$\rho(c,y)$	0.94	1.00	0.81	0.87	0.86
$\rho(u,y)$	−0.49	−0.48	−0.67	−0.53	−0.54
$\rho(n,y)$	0.49	0.48	0.67	0.53	0.54
$\rho(nxy,y)$	−0.21	−0.77	−0.47	−0.25	−0.26

Notes: The baseline model considers the case when none of the informal sector is captured in national statistics and unemployment is measured perfectly: y,c,u,n,nx denote y_f,c_f,u,n,nx in the model. The baseline model uses an external debt-elastic interest rate and sets $\psi=0.7$. 'DAC' denotes a model that is closed using debt adjustment costs with $\psi=0.7$. 'DAC recalib.' denotes a recalibrated model with debt adjustment costs and $\psi=0.7$.

Lastly, in column 5 we modify the number of job searchers to $u+\xi n_i$, where ξ is introduced to regulate the flow of informal sector workers searching for formal jobs.[24] The labor market tightness changes to $\theta=v/(u+\xi n_i)$, and the law of motion of formal employment becomes $n'_f=(1-s)n_f+p(u+\xi n_i)$. Using the ratio of average flows from informal to formal employment and from unemployment to formal employment in Mexico over the 1987Q1–2016Q4 period, ξ is calibrated to be 0.727. ξ restricts the number of informal workers searching for formal jobs, and hence a smaller fraction of informal workers can be reallocated in response to shocks. Therefore, the countercyclicality of the unemployment rate decreases. Other business cycle moments do not change much.

In the second set of sensitivity results reported in Table 8, we document the robustness of our main results to changes in the interest rate debt elasticity ψ and in the method used to close the small open economy model.

Schmitt-Grohé and Uribe (2003) provide several quantitatively equivalent approaches on how to eliminate the unit-root problem pertinent to small open economy models. We adopt the debt elastic interest rate approach and set the debt interest rate elasticity ψ to 0.7, a value estimated by Garcia-Cicco et al. (2010). Recently, de Groot et al. (2020) argue that some of the business cycle dynamics generated by a standard small open economy model can be sensitive to the value of ψ. In Table 8 we compare our baseline model moments with moments generated under different values of ψ and an alternative way of closing the model.

In columns 2 and 3, we vary ψ such that it takes a value that is ten times smaller or larger than its baseline value. As ψ increases, both the output and the relative volatility of consumption somewhat decrease, as well as the relative volatility and countercyclicality of the unemployment rate. The moments change in the other direction when ψ decreases.

In columns 4 and 5, we close the model by introducing debt adjustment costs (DAC). We eliminate the external debt interest rate component from the interest rate Eq. (17), and instead include a quadratic DAC function in the net exports equation, $nx=(1+r)d-d'+\psi(d'-\bar{d})^2$. We modify the associated first order conditions accordingly. For comparison purposes, we set ψ to its value in the baseline model. In column 4, we keep the remaining model parameters fixed at their baseline values. In column 5, we recalibrate the model to match the observed output volatility. The results demonstrate that the changes in the moments are small when closing the model with DAC.

Overall, Table 8 reveals that alternative ψ values and methods to close the model deliver similar results to the baseline model. It also shows that the changes in the moments are mostly pertinent to consumption and trade balance-to-output ratio dynamics, while labor market moments remain largely unaffected, consistent with the findings of de Groot et al. (2020).

[24] Note that in the baseline model $\xi=1$.

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	Slovakia	1995:1–2018:2	1994:1–2017:4
Spain	1980:1–2018:2	1986:2–2018:1	Slovenia	1995:1–2018:2	1996:1–2017:4
Sweden	1980:1–2017:2	1983:1–2018:2	Thailand	1993:1–2017:3	1998:1–2018:1
Switzerland	1980:1–2018:2	1993:1–2018:2	Turkey	1987:1–2018:2	2000:1–2018:1

7. 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 the informal economy. In particular, we show that the size of the informal economy is negatively related to the relative volatility of the unemployment rate to output, and the countercyclicality of the unemployment rate. Our small open two-sector economy model with asymmetric frictions between formal and informal labor markets replicates the documented cross-country unemployment rate dynamics, along with the differences in consumption and output volatility. In addition to the flow between formal employment and unemployment, the household has an alternative choice of working in the informal sector, which weakens the household's reliance on the unemployment margin. As a result, 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.

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Declaration of competing interest

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to https://doi.org/10.1016/j.euroecorev.2021.103949.

Appendix A. Data

In Table A.1, we provide country-specific sample windows for output (y) and unemployment rate (u) data used in our empirical analysis. The moments reported in Table 1 are computed on the overlapping sample of the output and unemployment rate series.

Appendix B. Informality, unemployment rate dynamics, and labor market flows

We examine the connection between unemployment rate fluctuations and other labor market statuses (out-of-labor force, formal employment, and informal employment) by analyzing the gross labor market flows in Mexico—a representative emerging market economy. We show that the flows of workers between total (formal and informal) employment and unemployment play a more important role for the unemployment rate dynamics than the flows between unemployment and inactivity (out-of-labor force).[25]

Using the data and approach in Leyva and Urrutia (2020), we obtain the gross flows among employment, unemployment, and out-of-labor force in Mexico over the 1987Q1–2004Q4 (ENEU survey) and 2005Q1–2016Q4 (ENOE survey) periods. Fig. B.1 quantifies the contribution of gross flows between (from/to) employment and unemployment, and between out-of-labor force and unemployment to fluctuations in the unemployment rate. In addition to the actual unemployment rate (solid black line), we plot the implied 'flow-based' unemployment rate (solid black line with a diamond symbol) constructed by allowing all flows among formal employment, informal self-employment, informal wage-earners, unemployment, and out-of-labor force to vary over the sample

[25] This finding is in line with the evidence provided in Shimer (2012) for the U.S.

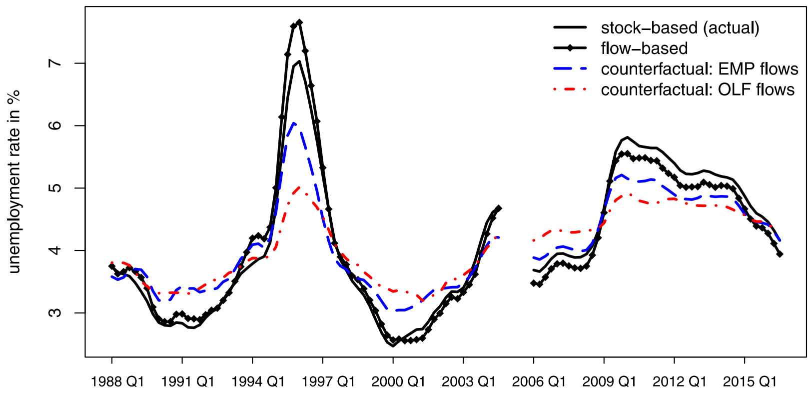

Fig. B.1. Labor market flows and unemployment rate dynamics in Mexico. Notes: The figure contrasts the contribution of employment–unemployment and out-of-labor force–unemployment flows to the unemployment rate fluctuations in Mexico over the 1987Q1–2004Q4 (ENEU survey) and 2005Q1–2016Q4 (ENOE survey) periods using data and methodology from Leyva and Urrutia (2020). 'stock based (actual)' plots the observed unemployment rate, while 'flow-based' plots the unemployment rate calculated using the composition of all gross flows among formal employed, informal wage-earner, informal self-employed, unemployed, and out-of-labor force. 'counterfactual EMP flows' denotes the unemployment rate that would have been observed if only the flows between employment and unemployment had been allowed to vary, while the rest of the flows would have equaled to their sample averages. The 'counterfactual: OLF flows' unemployment rate is calculated by allowing only the flows between out-of-labor force and unemployment to vary, while keeping the rest of the flows at their sample averages.

Table B.1
Contribution of labor market flows to unemployment rate variance in Mexico.

Unemployment rate	[1] n to u	[1.1] n^f to u	[1.2] n^i to u	[2] u to n	[2.1] u to n^f	[2.2] u to n^i	[3] olf to u	[4] u to olf
2005Q1–2016Q4 (ENOE)	50.6	17.2	33.4	15.5	19.3	−3.7	25.8	2.1
	(1.8)	(1.9)	(1.1)	(1.1)	(1.3)	(0.9)	(1.9)	(1.0)
1987Q1–2004Q4 (ENEU)	46.2	14.2	31.7	7.8	9.8	−1.7	30.5	4.8
	(1.0)	(0.9)	(0.5)	(0.8)	(0.5)	(0.8)	(0.9)	(0.8)

Notes: The table shows the fraction of the flow-based unemployment rate (computed as a percentage of labor force) variance in percent explained by gross flows between unemployment and employment (n), formal employment (n^f), informal (self-employed and wage earners) employment (n^i), and out-of-labor force (olf). The numbers refer to the estimated coefficients of β from the following regression with a third-order polynomial time trend: counterfactual rate$_t$ = $\alpha+\beta$flow-based rate$_t+e_t$. The numbers in parentheses denote the associated standard errors of β. The flow-based unemployment rate allows flows in all occupational categories to vary. The counterfactual unemployment rate allows only one type of flow, say from formal employment to unemployment (n^f to u), to vary and sets the remaining flows to their sample average.

period. The 'counterfactual: EMP flows' unemployment rate (blue long dash line) is computed by allowing only fluctuations in flows between total employment and unemployment and setting the remaining flows to their sample averages. The 'counterfactual: OLF flows' unemployment rate allows only the flows between inactivity and unemployment to change.[26]

Fig. B.1 reveals that flows between employment and unemployment contribute significantly more to unemployment rate fluctuations in Mexico than the participation margin. The counterfactual unemployment rate implied by the employment–unemployment flows tracks the observed unemployment rate much more closely, especially during the economic contractions of 1994–1996 and 2008–2009, than the one implied by the inactivity–unemployment flows.

In Table B.1 we use the variance decomposition and disaggregated labor market flows to provide supplementary evidence to Fig. B.1, showing that labor market flows between informal employment (self-employed and wage-earners) and unemployment explain an important fraction of the unemployment rate (computed as a percentage of labor force) fluctuations in Mexico.

Columns 1 and 2 show that the flows between total employment (n) and unemployment (u) account for close to two-thirds of the unemployment rate variance during the 2005–2016 period and for over half of the unemployment rate variance during the 1987–2004 period. The flows between out-of-labor force (olf) and unemployment (columns 3 and 4) explain on average less than a third of fluctuations in the unemployment rate. Table B.1 also shows that in addition to the flows between formal employment (n^f) and unemployment (columns 1.1 and 2.1), the flows between informal employment (n^i) and unemployment (columns 1.2 and 2.2) are a significant driver of unemployment rate dynamics.

Table B.2 provides evidence for the on-the-job search by informal workers. In particular, it reports the relative importance of flows between formal employment and unemployment, and between formal employment and informal employment for fluctuations in the formal employment rate in Mexico. The comparison of the first two columns (1 and 2) with the last two (3 and 4) reveals that the flows between formal and informal employment account for a comparable fraction of the variance in the formal employment rate as the one explained by the flows between unemployment and formal employment. In both periods, the two types of flows account jointly for over 70% of the formal employment rate dynamics.

[26] See Leyva and Urrutia (2020) and Shimer (2012) for more details on the labor market flow methodology.

Table B.2
Contribution of labor market flows to formal employment rate variance in Mexico.

Formal employment rate	[1] n^i to n^f	[2] n^f to n^i	[3] u to n^f	[4] n^f to u
2005Q1–2016Q4 (ENOE)	18.6	29.7	15.7	14.4
	(3.2)	(7.6)	(2.3)	(2.4)
1987Q1–2004Q4 (ENEU)	39.5	3.5	11.2	16.4
	(5.9)	(4.6)	(1.4)	(2.2)

Notes: The table shows the fraction of the flow-based formal employment rate (computed as a percentage of working-age population) variance in percent explained by gross flows between unemployment and employment (n), formal employment (n^f), informal (self-employed and wage earners) employment (n^i), and out-of-labor force (olf). The numbers refer to the estimated coefficients of β from the following regression with a third-order polynomial time trend: counterfactual rate$_t$ $= \alpha + \beta$flow-based rate$_t$ $+ e_t$. The numbers in parentheses denote the associated standard errors of β. The flow-based unemployment rate allows flows in all occupational categories to vary. The counterfactual formal employment rate allows only one type of flow, say from formal employment to unemployment (n^f to u), to vary and sets the remaining flows to their sample average.

Appendix C. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.euroecorev.2021.103949.

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