Firm dynamics, informality, and monetary policy

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Abstract

A prominent structural feature in many developing countries is the widespread prevalence of the informal economy, which usually operates as a form of insurance against downturns. Despite this knowledge, the effect of informality on inflation and output dynamics in developing countries remains little understood. This study asks to what extent monetary policy is stabilizing in economies with a large informal sector. First, through VAR analysis, we provide novel evidence of the counter-cyclical response of informal employment conditional on monetary policy shocks. Second, we examine the transmission mechanism of monetary policy through the lens of a two-sector New Keynesian (NK) model with endogenous firm entry to analyze the role of informality on sectoral reallocation, inflation, and output dynamics. For a plausible parametrization of the model, we quantitatively show that the presence of an informal sector implies a lower sacrifice ratio to monetary policy surprises, thereby enhancing the effectiveness of monetary policy. **JEL codes:** E23, E26, E31, E32, O17.

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1 Introduction

The COVID-19 pandemic greatly amplified the disparities between rich and poor countries. As the former countries, boosted by high vaccination rates and living standards, showed signs of a quick bounce back of their economies to pre-pandemic levels, the latter endured low vaccination rates and anemic recoveries. In short, the pandemic laid bare the fragility of low- and middle-income (henceforth developing) countries in dealing with the turmoil resulting from an unprecedented intersection of the two -health and economic- crises (World Bank 2020a, World Bank 2020b.)

On the economic policy front, while high-income countries employed a substantially generous mix of fiscal and monetary policies, developing countries struggled by being plagued with sick populations, lower growth, high inflation, and rising debt. Notably, the current unfavourable economic environment was further complicated as central banks in developing countries had to quickly withdraw monetary stimulus by raising interest rates to fight unusually high rates of inflation, which were worsened by sharp increases in energy prices due to the war in Ukraine. Importantly, in such an environment, it was unclear whether developing countries faced a higher cost of disinflation.

A prominent distortion in the economic structure of many developing countries is the prevalence of a large informal economy or informal production sector. The informal economy is referred to as legal, albeit underground, economic activity in the sense that it lacks regulatory accountability and government oversight. Furthermore, informality is unmeasured mainly in official government statistics. The issues associated with informality are compounded by the fact that most informal firms avoid paying taxes and fail to comply with government (i.e., labor and

product market) regulations. As a result, informality is associated with resource misallocation, low productivity, and low growth.

There are two key views in the policy debate about the role of the informal sector, namely 1) the informal sector is harmful to economic growth and welfare due to low levels of aggregate productivity and chronic socio-economic issues due to non-compliance with government regulations, and 2) the informal sector is beneficial in developing countries because it employs millions of people who cannot afford to be unemployed. There is still no consensus on this major policy issue, including among its prominent advocates, De Soto (1989) and its prominent critics, Levy (2010). Moreover, explicitly dealing with the informal sector with structural reforms is a thorny policy issue because politicians' and policy-makers' goals and time horizons are not usually aligned. The former is often concerned with short-run goals that benefit the incumbent government (i.e., to remain in power), and the latter is arguably more concerned with improving the country's (long-run) living standards.

A key strength of much of the literature on informality is its emphasis on the study of government policies whose stated goal is to reduce informality and promote formality in the long run. Such focus is certainly sensible because the size of the informal sector places an important burden on long-run development and growth. However, most of this literature has neglected the short-run impact of informality on the aggregate economy.

Notably, the informal sector is nearly absent in theoretical and empirical work on stabilization policy. An important exception is the study by Alberola and Urrutia (2020), which suggests that informality makes monetary policy less effective in stabilizing inflation.[1] Although counter-intuitive initially, their model rationalizes

[1]The working paper by Castillo and Montoro (2010) is the earliest study on the interaction of

their finding as informal production, assumed to be an intermediate good, responds pro-cyclically to demand shocks. As such, there are two key shortcomings to their model. First, these authors' assumption that the size of the informal sector is pro-cyclical conditional on demand shocks is counter-factual. Our study empirically shows that the informality rate is counter-cyclical conditional on monetary policy shocks, which is crucial to understand the effectiveness of monetary policy. Second, the study above considers informal goods to be intermediate goods, which is at odds with the widely accepted view that informal goods are final goods. The modelling choice above matters for the dynamic behaviour of informality as it implies a pro-cyclical behavior conditional on demand shocks. As a result, the authors conclude that informality is de-stabilizing. Our study challenges this view on empirical and theoretical grounds.

Our proposed framework is in the spirit of Ulyssea (2018), who develops a theoretical framework that introduces intra-sectoral firm reallocations in an economy with a large informal sector. In his framework, heterogeneous firms optimally choose to produce in the formal or informal sectors because entry into the formal sector is costly. Firms that choose to become informal avoid taxes and labor regulation costs but face a probability of being caught and an associated penalty. The cost of being informal is increasing in firm size. On the other hand, formal firms are subject to higher costs due to tax compliance and labor regulations. In equilibrium, entry into the formal sector is conditional on profitability subject to sunk (regulatory) costs. The number of firms that enter the formal market and the allocation of labor into formal and informal sectors is determined endogenously

monetary policy and informality, predicting –as in our study– a stabilizing role for informality. However, a key shortcoming of their model is its counterfactual prediction that the size of the informal sector is pro-cyclical.

by the firms' productivity and profitability.

Specifically, our paper considers the interaction of endogenous firm entry with the monetary policy transmission mechanism as in the seminal contributions of Bilbiie, Ghironi and Melitz (2008, 2012), henceforth BGM.[2] More importantly, our study examines the implications of endogenous firm entry in an environment with a large informal sector for sectoral reallocation (between formal and informal sectors), and aggregate dynamics (inflation and output) over the business cycle.

The key contributions of this study are twofold. First, we provide novel empirical evidence on the counter-cyclical response of the size of the informal sector conditional on monetary policy shocks. We argue that this new evidence is central to better understanding the transmission mechanism of monetary policy in economies with a large informal sector. Second, we theoretically examine the interaction of endogenous entry and monetary policy in an economic environment with a large informal sector, a prominent structural feature in many developing countries. In this environment, interest rates play an important role in formal firm entry and product creation decisions because the market value of formal firms, and correspondingly their profitability, depends on financial market conditions as reflected by interest rates. In contrast, informal firms lack access to credit, which makes informal firms less sensitive to financial market conditions.

The mechanism works as follows. A monetary easing leads to an increase in the household's demand for goods of different varieties. Due to nominal rigidities in the formal sector, formal goods are relatively cheaper than informal goods, resulting in higher demand of the former at the expense of the latter. Expenditure switching drives a higher demand for formal employment, which in turn lowers

[2] As in BGM, we focus on the interaction between firm entry and nominal rigidities rather than heterogeneous productivity.

informal employment. As a result, monetary surprises are associated with counter-cyclical informal labor as documented by our empirical evidence. Notably, due to the sectoral labor margin of adjustment, informal labor serves as an employment buffer; and monetary policy is more effective in stabilizing output and inflation.

This paper is organized as follows: Section 2 describes a New Keynesian model with formal and informal production featuring endogenous firm entry into the formal sector, section 3 discusses the calibration of the model for the case of Mexico, a representative economy with a large informal sector, section 4 analyses the business cycle implications of the firm dynamics model with informality, and the last section concludes.

2 Empirical evidence

In this section, we provide novel empirical evidence on the effect of monetary policy on informal employment. We extend Bergin and Corsetti (2008) vector autoregression model of firm dynamics and apply it to estimate the dynamic effects of monetary policy shocks on the size of the informal sector for the case of Mexico. We now proceed to describe the data and the empirical methodology.

2.1 Data

Our empirical analysis employs quarterly data for Mexico for the period 2005Q1:2019Q4.[3] We use the following variables for estimation: Country-specific commodity price index, Real GDP, GDP deflator, short-term interest rate (3-month treasury bill

[3]The availability of quality time series data on informal employment guides our choice of Mexico as a representative country with a large informal sector.

rate), Mexican stock market index (Indice the Precios y Cotizaciones, IPC), and two measures of the informality rate.

As labor informality is often difficult to measure accurately, we employ two series of informal employment in our analysis. Namely:

1. Employment in the informal sector (15 years of age and above) as a share of total employment (IFR)

2. Wage-earners (employed by unregistered businesses and/or without access to health care through social security) and informal self-employed (running unregistered businesses) as share of population (IFE5)

National accounts data is obtained from OECD. The first measure of the informality rate is constructed using labor data from INEGI (National Institute of Statistics and Geography). The second informality measure, which represents the population share of informal employment, is based on the dataset by Leyva & Urrutia (2020). Mexico's commodity terms-of-trade net export index is from IFS (IMF Financial Statistics), and Mexico's stock market index is from Yahoo Finance.

2.2 Vector autoregression

To examine empirically the impact of monetary policy shocks on informal employment we draw on Bergin and Corsetti (2008) vector autoregression model in levels. In contrast to Bergin and Corsetti (2008), who study the effect of monetary policy on firm entry in the U.S., we examine the dynamic effects of monetary policy shocks on informal firms proxied by informal employment.

Due to the lack of quarterly frequency data on firm entry in Mexico (both formal and informal), we use informal employment as a proxy for informal firm

entry. This is sensible based on Abreha et al. (2022), who document that the size distribution of informal firms is highly skewed toward the left with very small firms (between 1 to 4 workers.) In the same vein, we use Mexico's stock market index as a proxy for formal firms' profits.

We estimate the structural vector autoregression model with a subset of the model variables:

$$X_t = a_0 + \sum_{i=1}^{p} A_i X_{t-i} + B\epsilon_t,$$

where a_0 is a vector of constants and linear trends, X_t is an $n \times 1$ vector of variables, A_i are coefficient matrices, and ϵ_t are normally distributed, mutually and serially uncorrelated innovations with unit variance, i.e., $\epsilon_t \sim N(0, I)$.

The VAR model is estimated using log levels of the macro variables and percent values of the ratio variables. We estimate the models based on optimal lag lengths (i.e., 1-lag for model one and 2-lags for model 2). Our identification strategy draws on Bergin and Corsetti (2008) with the following modifications. First, we order the country-specific commodity price index consistent with the assumption that the representative economy is small and takes world prices as given. Secondly, our new variable on the informality rate is ordered last, consistent with the assumption that sectoral labor market conditions respond contemporaneously to external shocks and aggregate economic conditions. Finally, due to data constraints, we use firms' market value (stock market index) as a proxy for (formal) firms' profit.[4]

[4]Our VAR results are robust to alternative plausible orderings of the variables. Results are available upon request from the author.

2.3 VAR results

We estimate two VAR models using two different measures for the size of the informal sector, respectively. The first measure tracks informal employment as a share of total employment and is collected from INEGUI for the period 2005Q1: 2019Q4. The second measure uses the data from Leyva Urrutia (2020) and captures both informal wage earners and the self-employed as a share of working population for 2005Q1:2016Q4. The estimated impulse responses of informal employment to a one standard deviation increase in the short-term interest rate in México are shown in Figures 1 and 2.

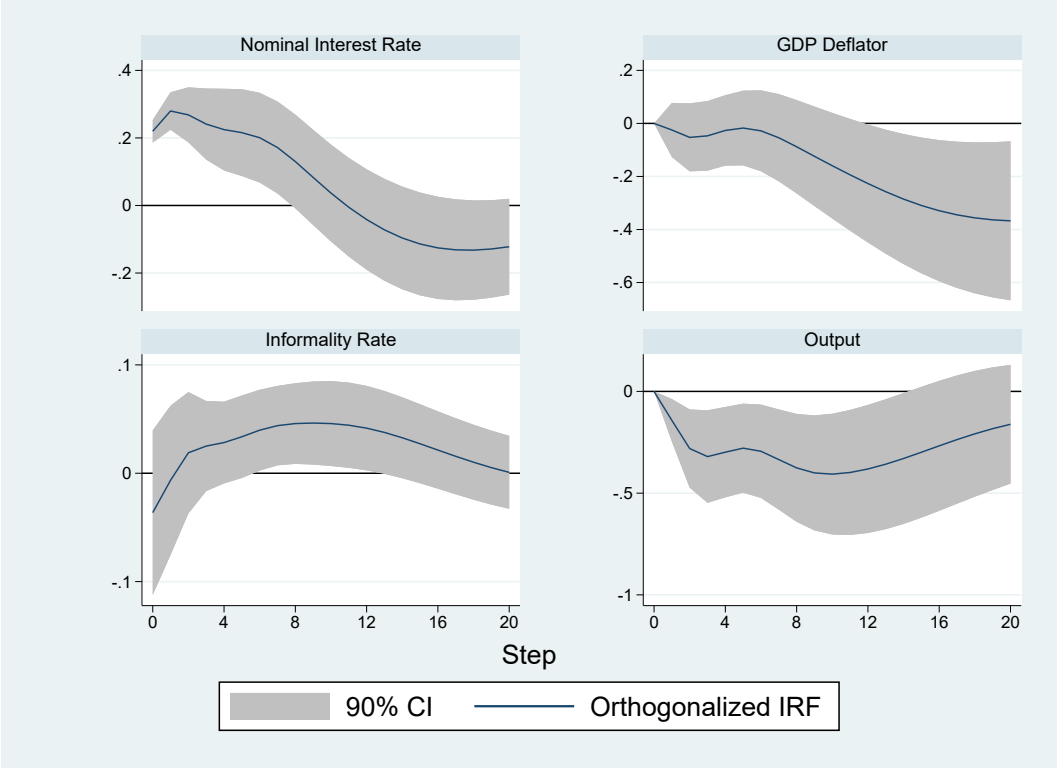

Figure 1: Effect of a monetary policy shock (Informal employment as share of total employment.)

The VAR results provide evidence of a positive impact of rising interest rates on the informality rate. These results indicate that the informality rate is counter-cyclical conditional on monetary surprises.

Next, we estimate the same VAR using the population share of informal employment. The dynamic responses to a rise in interest rates show that the population share of the informal sector increases. Overall, the VAR evidence of the two measures of the size of the informal sector is consistent with a counter-cyclical response of the size of the informal sector conditional on monetary surprises. Further, the magnitude of both estimated impulse responses is quantitatively similar.

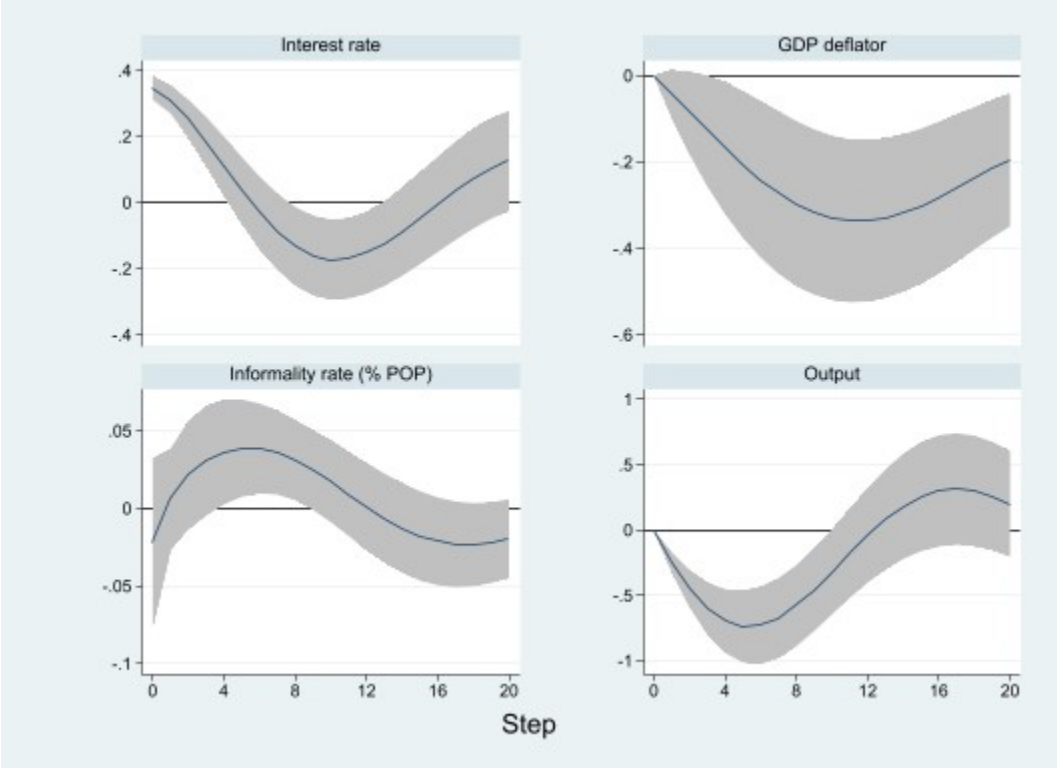

Figure 2: Effect of a monetary policy shock (Informal employment as share of working population, 68% CI.)

Given the suggestive evidence on the counter-cyclical response of the informality rate to monetary surprises, we theoretically investigate the transmission mechanism of monetary policy shocks in an economy with a large informal sector.

3 Model

The model is a two-sector version of the monetary model with endogenous firm entry as in Bilbiie, Ghironi, and Meltiz (2008). The economic environment is populated by a representative household whose utility is derived from the consumption of formal and informal goods and time spent at home. The economy has two production sectors: formal firms that are regulated and sell a differentiated market good under sticky prices and a representative informal firm that evades regulation and sells final goods under perfect competition.

3.1 Household preferences

A unit mass of atomistic, identical households populates the economy. All contracts and prices are written in nominal terms. The composition of the consumption basket changes over time because of firm entry in the formal sector. We abstract from monetary frictions that would motivate a demand for cash currency, and we resort to a cashless economy following Woodford (2003). The members of the representative household supply formal L_t^F and informal labor L_t^{NF} each period t in a competitive labor market, otherwise the members of the household are assumed to be non-active in the labor market $O_t = 1 - L_t^F - L_t^{NF} = 1 - L_t$.

The representative household maximizes expected intertemporal utility,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln C_t - \chi (L_t^F)^{1+1/\phi}/(1+1/\phi) - \chi (L_t^{NF})^{1+1/\phi}/(1+1/\phi) \right),$$

where $\beta \in (0,1]$ is the discount factor, C_t is a consumption basket that aggregates formal and informal goods, and hours worked are allocated between formal L_{Ft} and informal L_{NFt} sectors.

Consumption is a C.E.S. composite of formal and informal goods, C_t^F and C_t^{NF}:

$$C_t = \left[\alpha^{\frac{1}{\theta}} (C_t^F)^{\frac{\theta-1}{\theta}} + (1-\alpha)^{\frac{1}{\theta}} (C_t^{NF})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{1-\theta}},$$

where $\alpha \in (0,1]$ is the share of formal goods in the consumption basket, and θ denotes the constant elasticity of substitution between formal and informal goods. The consumption price index is $P_t = \left[\alpha (P_t^F)^{1-\theta} + (1-\alpha)(P_t^{NF})^{1-\theta} \right]^{\frac{1}{1-\theta}}$, where P_t^F is the price of the formal good and P_t^{NF} is the price of the informal good.

3.2 Production

There are two sectors producing final consumption goods. A formal producing sector is populated by a continuum of monopolistically competitive firms that purchase intermediate inputs and produce differentiated varieties, and an informal production sector where perfectly competitive firms combine intermediate inputs to produce a consumption good.

3.2.1 Formal sector

There is a continuum of monopolistically competitive firms, each producing a different variety $\omega \in \Omega$. The formal production sector draws on Bilbiie, Ghironi and Melitz (2008) (henceforth BGM08). Firms in this sector can alternatively be interpreted by considering each productive unit in the model as a production line that could be part of a multi-product firm. Under this interpretation, firm entry and exit reflect the product-switching dynamics within firms, as Bernard, Redding and Schott (2010) reported.

Production in the formal sector requires only one factor, labor. Aggregate labor productivity in the formal sector is indexed by $Z^F t$, which represents the effectiveness of formal labor. Formal productivity Zt^F is exogenous and follows an AR(1) process (in logs). Output supplied by firm ω is $y_t^F(\omega) = Z_t^F l_t^F(\omega)$, where $l_t^F(\omega)$ is the firm's labor demand for productive purposes. The unit cost of formal production, in units of the consumption basket C_t, is w_t^F / Z_t^F, where $w_t^F \equiv Wt^F / Pt$ is the real wage in the formal sector.

The number of firms in the formal sector is endogenous. Before entry, firms face a sunk entry cost of f_E effective labor units, equal to $w_t^F f_E / Z_t^F$ units of the consumption basket. In this setup, we interpret the entry cost as an exogenous regulatory cost incurred by a firm that plans to operate in the formal sector. All firms that enter the economy produce every period until they are hit by a "death shock," which occurs with probability $s \in (0, 1)$ every period.

Formal firms face nominal rigidities in the form of a quadratic cost of adjusting prices over time (Rotemberg 1982). In particular, the real cost (in units of consumption) of output-price inflation volatility around a steady-state level of zero inflation facing firm ω is $\Gamma_t^F(\omega) \equiv \kappa(\pi_t^F(\omega))^2 p_t^F(\omega) y_t^D(\omega)/2$, where $\kappa > 0$ deter-

mines the size of the adjustment cost (prices are flexible if $\kappa = 0$), $p_t^F(\omega) \equiv P_t^F/P_t$ is the real price of formal-good ω, $y_t^D(\omega)$ is firm ω's output demand, and formal sector inflation is given by $\pi_t^F(\omega) \equiv (P_t^F(\omega)/P_{t-1}^F(\omega) - 1)$. This price adjustment cost can be interpreted as the bundle of goods the firm needs to purchase when implementing a price change. Its size is assumed to be larger when the size of the firm (measured by its revenue) increases.[5]

The total demand for the output of formal firm ω is then

$$y_t^D(\omega) \equiv \left[p_t^F\right]^{-\theta} \left((C_t^F + N_t^F \Gamma_t^F(\omega)\right),$$

where N_t^F denotes the number of formal firms producing at time t, and we use symmetry across firms in the definition of the aggregate demand of the consumption basket for price adjustment purposes.

Drawing on Neumeyer & Perri (2005), we assume that part of formal labor demand is financed. That is, formal firm ω's cost of labor is subject to a working capital constraint, which is financed at the nominal interest rate i_t. We derive formal firm ω's real profit in period t (distributed to households as dividend) as

$$d_t^F = p_t^F(\omega) y_t^D(\omega) - (1 + \gamma i_t) w_t^F l_t^F(\omega) - \frac{\kappa}{2}\left[\pi_t^F\right]^2 p_t^F y_t^D,$$

where i_t is the short-term nominal interest rate and $\gamma \in (0, 1)$ represents the working capital friction.

The real value of formal firm ω at time t (in units of consumption) is the expected present discounted value of future profits from $t + 1$ on, discounted with

[5] As in BGM08, we assume symmetry across producers so that when a new formal-good firm sets the price of its output for the first time, it takes the $t - 1$ price in the adjustment cost relation as the notional price that the firm would have set at time $t - 1$ if it had been producing in that period.

the household's stochastic discount factor $v_t(\omega) = E_t \sum_{i=t+1}^{\infty} \Lambda_{t,i} d_i^F(\omega)$, where $\Lambda_{t,i} \equiv [\beta(1-s)]^{i-t} U_C(C_i, L_i)/U_C(C_t, L_t)$ is the discount factor applied by households (which faces a probability s of being hit with the "death" shock in each period).

At time t, formal firm ω chooses $l_t^F(\omega)$ and p_t^F to maximize $d_t(\omega) + v_t(\omega)$ subject to $y_t^F = y_t^D$, taking w_t, P_t, C_t, Γ_t^F, and Z_t as given. Letting $\lambda_t(\omega)$ denote the Lagrange multiplier on the constraint $y_t^F = y_t^D$, the first order condition with respect to l_t^F in symmetric equilibrium yields

$$\lambda_t Z_t = w_t(1 + \gamma i_t).$$

The productivity adjusted shadow value of an extra unit of formal output is given by the formal firm's unit cost of labor, including the working capital cost, and this shadow value is common across all formal firms in the economy.

The first order condition with respect to p_t^F yields $p_t^F - \mu_t(\omega)\lambda_t(\omega)$. Formal firm ω sets the price as a markup $\mu_t(\omega)$ over real marginal cost, where the markup is given by:

$$\mu_t(\omega) \equiv \frac{\epsilon(\omega) y_t^F(\omega)}{(\epsilon(\omega) - 1) y_t^F(\omega) \left\{1 - \frac{\kappa}{2}\left[\pi_t^F(\omega)\right]^2\right\} + \kappa\Theta_t},$$

$$\Theta_t \equiv y_t^F(\omega)(1 + \pi_t^F)\pi_t^F - E_t\left\{\Lambda_{t,t+1} y_{t+a}^F(\omega) \frac{P_t}{P_{t+1}} [1 + \pi_{t+1}^F(\omega)]^2 \pi_{t+1}^F\right\}.$$

The markup reduces to $\epsilon(\omega)/(\epsilon(\omega) - 1)$ in the absence of nominal rigidity ($\kappa = 0$) or if p_t^F is constant. Importantly, markup variation comes from price stickiness, as the cost of adjusting prices gives formal firms an incentive to change their markups over time to smooth price changes across periods.

Log-linearization of the markup equation yields the model's New Keynesian

Phillips curve, incorporating the effect of endogenous firm entry.

3.2.2 Firm entry and exit

Prospective entrants to the formal sector are forward-looking and form rational expectations of their future profits $d_i^F(\omega)$ in any period $i > t$ subject to the exogenous probability s of incurring an exit-inducing shock by the end of each period. As in BGM08, there is a time-to-build lag, so entrants at time t will become productive only at $t+1$. Our assumptions on exit shocks and the timing of entry and production imply that the law of motion for the number of formal firms is given by $N_t^F = (1-s)(N_{t-1}^F + N_{E,t-1})$. In the model, the present discounted value of current and future profits is equivalent to the average value of formal firms $v_t(\omega)$ after production has occurred. Entry occurs until firm value is equalized with the entry cost, leading to the free entry condition $v_t(\omega) = w_t f_E / Z_t$. This condition holds so long as the mass $N_{E,t}$ of entrants is positive. We assume that macroeconomic shocks are small, so this condition holds every period.

3.2.3 Informal sector

A unit mass of perfectly competitive, symmetric firms produce an informal consumption good, y_t^{NF}. Production requires only labor input. The production function is $y_t^{NF} = \varkappa Z_t^{NF} l_t^{NF}$, where l_t^{NF} denotes informal labor input, Z_t^{NF} is productivity in the informal sector, and $\varkappa \in (0,1)$ is the parameter that denotes lower average productivity level of informal labor.

Under perfect competition, the representative informal firm takes the output

price as given. Let d_t^{NF} denote informal firm's profit given by

$$d_t^{NF} = (1 - \rho_t^i)\phi P_t^{NF} y_t^{NF} - W_t^{NF} l_t^{NF},$$

where P_t^{NF} is the nominal price of informal output, W_t^{NF} is the nominal wage in the informal sector, ρ_t^i denotes the probability of informal firm i being caught, and ϕ is the output share of the non-compliant firm that is confiscated when caught. As in Restrepo(2014), the probability of catching an informal firm is a function of the size of the firm $\rho_t^i = f(l_t^{NF})$.

The representative informal firm problem is static. The firm chooses informal labor l_t^{NF} to maximize real profits. Residual profits from operating the informal firm are rebated to the household as a lump sum. The first order condition for informal labor demand is

$$w_t^{NF} = (1 - \rho_t^i)\phi p_t^{NF} \varkappa Z_t^{NF}$$

where $p_t^{NF} = P_t^{NF}/P_t$ denotes the real price of informal labor, and w_t^{NF} is the real wage in the informal sector.

3.3 Household budget constraint and intertemporal decision

The representative household can invest in two types of assets: Shares in a mutual fund of formal sector firms and domestic bonds. Let x_t be the share in the mutual fund of formal firms held by the representative household entering period t. The mutual fund pays a total nominal profit in each period equal to the total profit of all formal firms producing at that period, $P_t N_t^F d_t^F$. During period t, the representative household buys x_{t+1} shares in a mutual fund of $N_t^F + N_{E,t}$ formal

firms (those operating at time t and new entrants). Only a fraction $(1-s)$ of these firms will produce and pay dividends at period $t+1$. Since the households do not know which firms will be hit by the exogenous exit shock s at the end of period t, it finances the continuing operation of all pre-existing formal firms and all new entrants during period t. The date t price of a claim to the future profit stream of the mutual fund is equal to the nominal price of claims to future profits of formal firms, $P_t v_t^F$.

Similarly, the household enters period t with nominal bond holdings $B_{N,t}$ of domestic debt and receives gross interest income on these holdings in period $t+1$. Finally, the household members receive labor income from working in formal and informal firms. The household allocates these resources between purchases of bonds and shares to be carried into the next period and consumption. The period budget constraint in real terms (in units of the consumption good) is:

$$B_{t+1} + v_t(Nt^F + N_{E,t})x_{t+1} + C_t =$$

$$(1 + r_{t-1})B_t + (d_t^F + v_t)N_t^F x_t + (1-\tau_t)w_t^F L_t^F + w_t^{NF} L_t^{NF} + T_t,$$

where r_{t-1} denotes the real interest rates on holdings of bonds between $t-1$ and t, d_t^F denotes real dividends from formal sector firms, τ_t is a labor income tax to formal sector employment, $B_t \equiv B_{N,t}/P_{t-1}$ denotes real bond holdings, and T_t denotes a lump-sum tax (or transfer) from the government. From the Fisher relation, the gross nominal interest rate is $1 + i_{t-1} \equiv (1 + r_t)(1 + \pi_t)$, with $\pi_t \equiv P_t/P_{t-1} - 1$.

The Euler equations for bonds and share holdings are $C_t^{-1} = \beta E_t\left[(1 + r_{t+1})C_{t+1}^{-1}\right]$, and $v_t = \beta(1-s)E_t\left[\frac{C_t}{C_{t+1}}(v_{t+1} + d_{t+1}^F\right]$.

The first-order conditions for the optimal choice of labor effort in each production sector requires that the marginal disutility of labor be equal to the marginal utility from consuming the real wage received from an additional unit of labor $\chi(L_t^F)^{1/\phi} = (1-\tau)\frac{w_t^F}{u_{C_F,t}}$ and $\chi(L_t^{NF})^{1/\phi} = \frac{w_t^{NF}}{u_{C_{NF},t}}$.

3.4 Aggregate Accounting and Equilibrium

Aggregating the household budget constraint and imposing the equilibrium conditions $B_{t+1} = B_t = 0$ and $\varkappa_{t+1} = \varkappa_t = 1$, $\forall t$, yields the aggregate accounting identity for GDP, $Y_t \equiv C_t + N_{E,t} + G_t = w_t^F L_t^F + w_t^{NF} L_t^{NF} + N_t d_t^F$.

Labor market equilibrium requires $(N_t^F l_t^F + N_{E,t} f_{E,t}/Z_t^F) + L_t^{NF} = L_t$: The total amount of labor used in the production of formal and informal goods, in addition to the setup of new formal firms must equal labor supply.

3.5 Monetary policy and closing the model

The model is closed by specifying a rule for nominal interest rate setting by the monetary authority, which responds to movements in average CPI inflation, as well as the government budget constraint.[6]

In the presence of endogenous producer entry and preferences exhibiting "love for variety," it is important to identify the empirically relevant variables that enter the monetary policy reaction function. Therefore, we follow Ghironi and Melitz (2005) and use the firm-level price p_t^F as the data-consistent price index. Therefore, given any variable X_t in units of consumption, the data consistent counterpart is given by $\tilde{X}_t \equiv X_t \frac{P_t}{p_t^F}$.

[6]We assume that the representative emerging economy central bank has as objective price stability, consistent with the behavior of most central banks in emerging economies.

As in BGM2008, the central bank goal sets the nominal interest rate under the following Taylor-type inflation targeting rule:

$$1 + i_t = (1 + i_{t-1})^{\rho_i} \left[(1 + \bar{i})(\frac{\Pi_t^F}{\Pi_{ss}^F})^{\rho_\pi} \right]^{1-\rho_i} \eta_t,$$

where Π_t^F denotes (formal) producer gross inflation, Π_{ss}^F is steady state (wholesale sector) gross inflation, η_t is a white noise shock process with zero mean and variance σ_η^2. Lastly, $\rho_i > 0$, $\rho_\pi > 0$.

On the fiscal side, we assume that the government spends a fraction of output g_t each period and that it finances its spending from formal employment payroll taxes and confiscated revenue from non-compliant informal firms:

$$g_t Y_t = \tau w_t^F L_t^F + \rho_t^i \phi P_t^{NF} y_t^{NF}.$$

4 Calibration

We calibrate the model for the case of México, a country well-documented in the literature to be a representative economy with a large informal sector (Fernandez and Meza 2014, Yépez 2019, Leyva and Urrutia 2020, Hovarth and Yang 2022, Lama, Leyva and Urrutia 2022). Table 1, panels A and B, show the summary of the calibrated parameters.

A period in the model corresponds to a quarter. The first set of parameters is standard from the literature. Namely, we set $\beta = 0.99$, implying a long-run annualized real interest rate of 4%. The size of the exogenous firm exit shock is $\delta = 0.025$ akin to an annual depreciation rate of 10% per year. As in the canonical model of BGM2008, $\theta = 3.8$ and the price stickiness parameter is $\kappa^p = 77$. Last,

the inflation targeting policy rule coefficients are set to $\rho_i = 0.8$ and $\rho_\pi = 1.5$ as in BGM2008, while the working capital parameter is set at $\gamma = 0.21$, as in Pratap et al. (2019).

The second set of parameters is calibrated to match key steady-state targets for México. The inverse-Frisch labor elasticity parameter is $\phi = 0.5$, implying a labor supply elasticity of 2. Next, following Bachas et al. (2023), we set the elasticity of substitution between formal and informal goods at 1.5. This latter parameter is of similar magnitude but lower than in RBC models with home production (Chen et al., 2018) and informality (Restrepo-Echavarria, 2014; Fernandez and Meza, 2015). Therefore, in the robustness section, we check for sensitivity to higher elasticity values of this key model parameter.

Panel B presents the shock parameters. The persistence of formal productivity shocks is set to $\rho^f = 0.975$ to match the first-order auto-correlation of measured output. The standard deviation of formal productivity is $\sigma^f = 0.12$, matching the volatility of output in the data. The persistence and standard deviation of informal productivity parameters are $\rho^n = 0.9$ and $\sigma^n = 0.01$. They are meant to be suggestive due to the lack of observability of target data moments of informal production. Next, the supply price shock process is modelled using an AR(2) process commonly employed in the literature for commodity price shocks. Namely, the first AR parameter is set to $\phi^{p1} = 0.9$ and the second AR parameter to $\phi^{p2} = -0.1$. The standard deviation of the price shock is set to $\sigma^p = 0.02$ to match the volatility of CPI inflation in the data. Last, the standard deviation of monetary surprises is set to $\sigma^r = 0.01$ to match the real interest rate volatility in the data.

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Discount factor	β	0.99
Depreciation rate	δ	0.02
Inverse Frisch elasticity*	ϕ	0.50
Working capital friction	γ	0.21
Elasticity of substitution:		
- Across formal goods	θ^F	3.80
- Between formal and informal goods	θ	1.50
Implied labor income tax rate*	τ	0.20
Interest rate inertia parameter	ρ_i	0.80
Inflation weight coefficient	ρ_π	1.50

Table 1A. Structural parameters (benchmark specification, quarterly).

*Source: BGM 2008, Pratap et al. (2019), Bachas et al. (2023), *Author's calibration*.*

Shock parameters

Productivity persistence (Formal sector)*	ρ_z^F	0.97
Productivity persistence (Informal sector)	ρ_z^N	0.90
Productivity standard deviation (Formal sector)*	σ_z^F	2.40
Productivity standard deviation (Informal sector)	σ_z^N	0.01
Price shock AR parameter 1	ρ_{p1}^F	0.9
Price shock AR parameter 2	ρ_{p1}^F	-0.1
Price shock standard deviation*	σ_p	0.02
Monetary policy standard deviation*	σ_p	0.01

Table 1B. Productivity processes (benchmark specification, quarterly).

*Source: *simulated*.*

5 Inspecting the mechanism: Firm dynamics and informality

We now use the calibrated model to analyze the channels through which different shocks are transmitted into the economy. Without loss of generality, in our initial analysis using impulse responses, we consider the optimal policy of *zero* wholesale price inflation in a second-best environment without tax subsidies (Bilbiie, Fujiwara and Ghironi, 2014), along with three simple interest rate rules. Namely, wholesale inflation targeting ($i_t = 1.5E_t\pi^F_{t+1}$), a Taylor-type (wholesale) inflation targeting rule ($i_t = 0.8i_{t-1} + 0.3E_t\pi^F_{t+1}$), and a CPI-inflation targeting rule ($i_t = 1.5E_t\pi^{cpi}_{t+1}$).[7] We first consider the impact of lowering the entry cost to formality on sectoral re-allocation and output. Second, we examine a positive productivity shock in formal production. Third, we analyze and discuss firm dynamics in response to a monetary policy surprise. Last, we discuss the dynamic responses to a price (supply) shock.

5.1 Impulse responses

Entry cost

[7]The wholesale inflation and output gap rule (not shown) is the closest to the optimal policy rule and is omitted for brevity. Further, recall that the total (formal and informal) CPI price level is unobserved by the central bank by assumption.

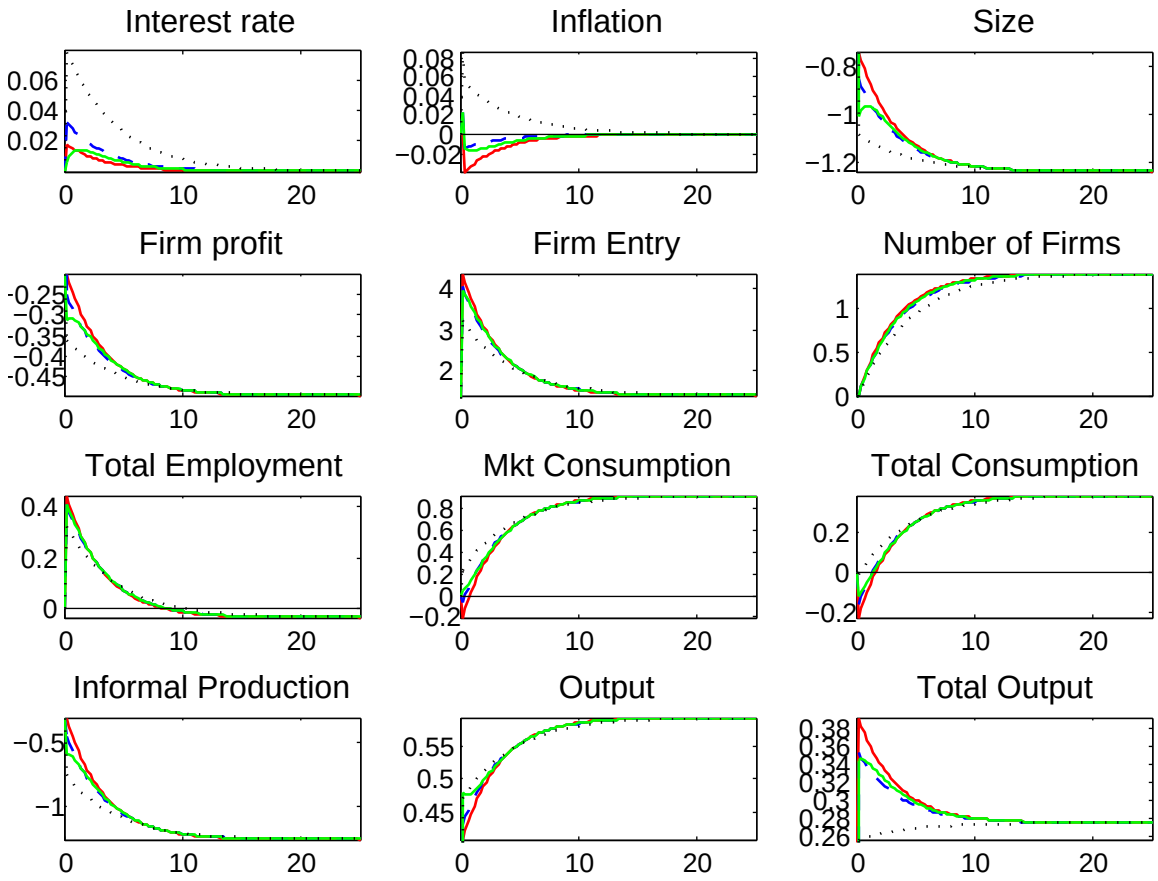

Figure 3. Impulse responses: Reduction in entry cost to formalization. Red (solid): optimal policy. Blue (dash): $i_t = 1.5E_t\pi_{t+1}$. **Green (solid):** $i_t = 0.8i_{t-1} + 0.3E_t\pi_{t+1}$. **Black (dot):** $i_t = 1.5E_t\pi^{cpi}_{t+1}$.

Figure 3 shows the economic responses to a 1% permanent decrease in the entry (i.e., regulatory) cost of formal production. The model predictions are consistent with the well-known stylized fact that barriers to formalization are strongly associated with the existence of an informal sector. As the entry cost to formality falls, firm profits and entry increase, leading to a permanently higher number of formal firms. Labor re-allocates permanently from informal employment to formal employment, as shown by the decrease

in the size of the informal sector by more than 1% in the long run. Formal (market) consumption and total consumption increase permanently, leading to a permanent increase in measured (formal) output. However, the decline in informal production implies that total (unmeasured) output does not increase as much (relative to measured output) in the long run.

Finally, in terms of the monetary policy rules, CPI-inflation targeting is the rule that deviates most from the optimal policy in the short and medium run, driven by higher inflation and higher interest rates.

Productivity

Figure 4 shows the dynamic responses to a productivity shock in the formal sector. An increase in the productivity of the formal sector drives higher profits, which encourages firm entry along with formal firms' labor demand. Demand for formal products increases as their prices fall, boosting output. Given the fixed labor supply, formal firms draw labor from the informal sector, lowering informal production. Regarding the monetary policy responses, the cpi-inflation targeting rule results in higher inflation on impact, requiring a more aggressive increase in interest rates relative to the optimal policy. The other policy rules have a qualitatively close behaviour as the optimal rule, where inflation initially falls, requiring a small interest rate response. Otherwise, there are negligible differences in the response of real variables to a formal productivity shock.

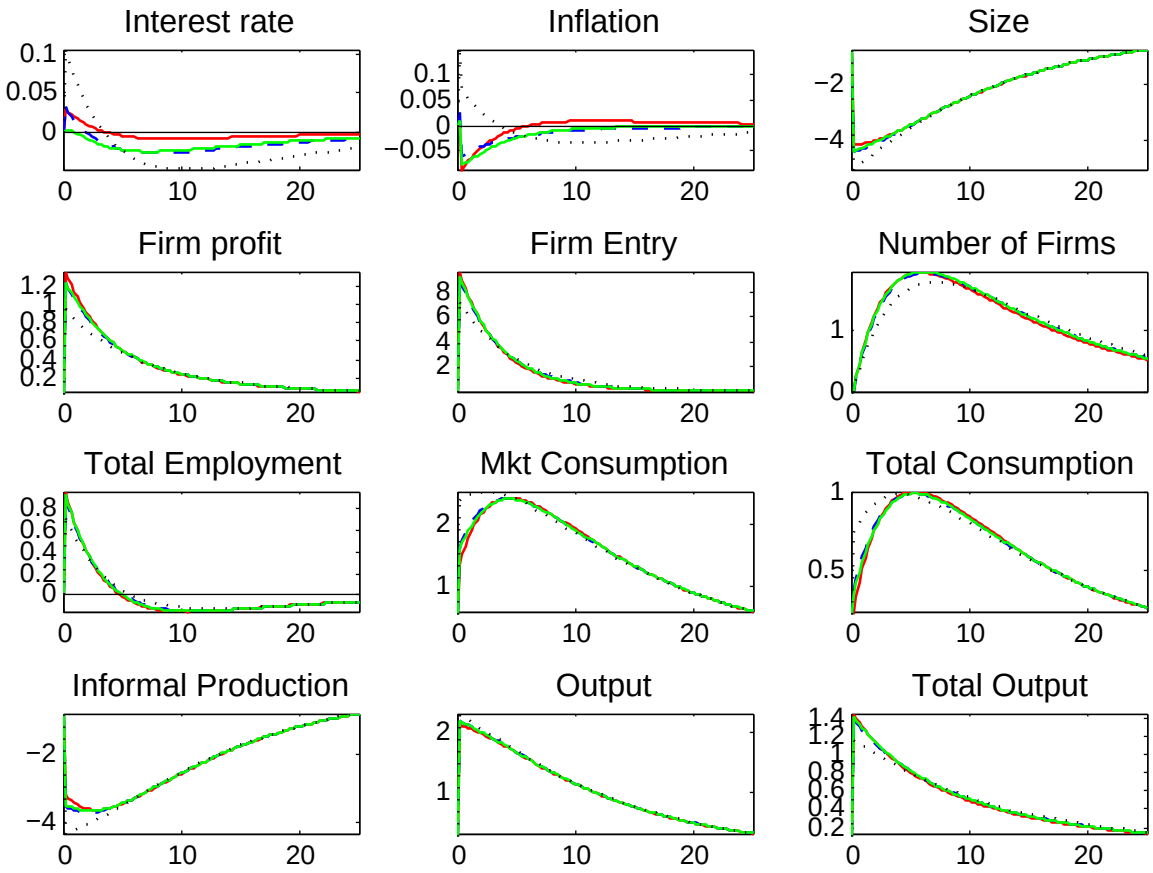

Figure 4. Impulse responses: Productivity shock in the formal sector. Red (solid): optimal policy. Blue (dash): $i_t = 1.5E_t\pi_{t+1}$. **Green (solid):** $i_t = 0.8i_{t-1} + 0.3E_t\pi_{t+1}$. **Black (dot):** $i_t = 1.5E_t\pi^{cpi}_{t+1}$.

Monetary policy

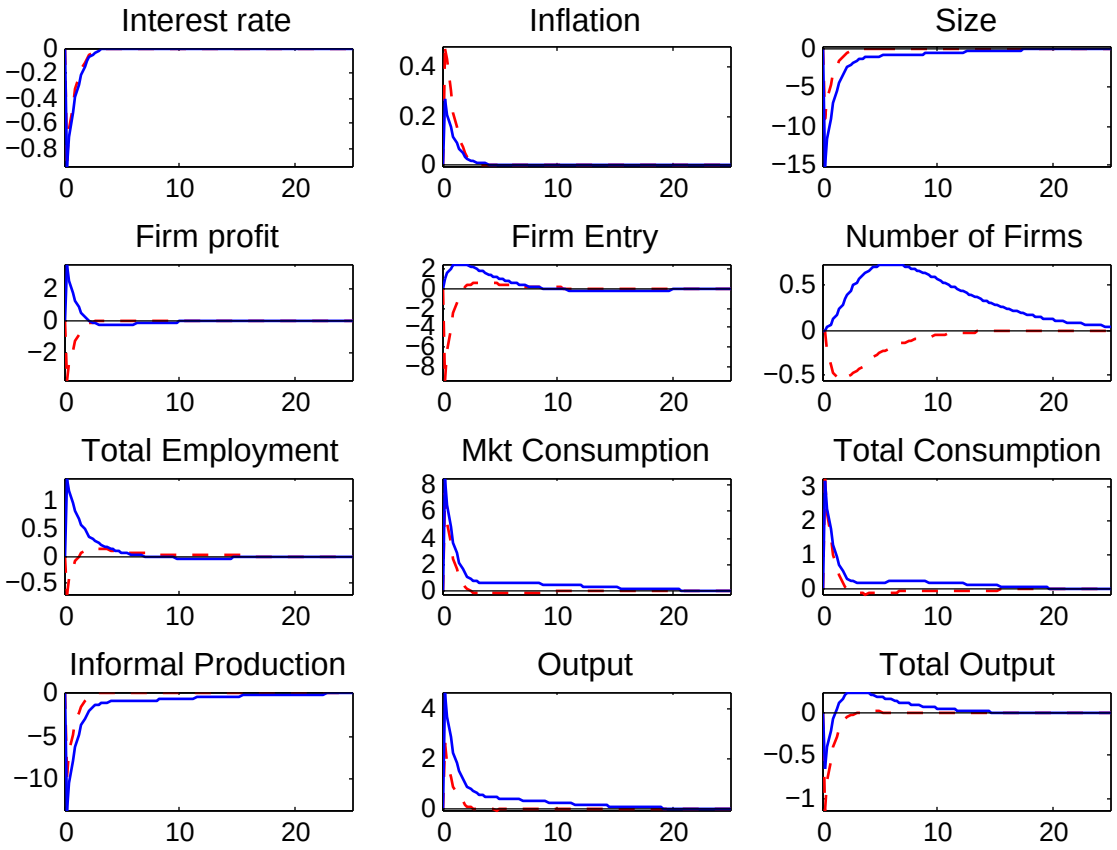

Figure 5. Impulse responses: Interest rate shock under $i_t = 0.8i_{t-1} + 0.3E_t\pi_{t+1}$ rule. Red (dash): Benchmark model. Blue (solid): Extended model (wage rigidity and congestion externalities.)

We now examine the transmission mechanism of firm entry to a momentary policy shock that lowers the interest rate by 1%. Without loss of generality, we limit the discussion to the interest rate rule $i_t = 0.8i_{t-1} + 0.3E_t\pi^F_{t+1} + \nu_t$. Figure 5 shows the responses of the benchmark model (red dash lines). The interest rate cut generates inflation and a positive

response of consumption and output—nominal wages (not shown) increase, lowering labor demand. In particular, firm entry falls due to two channels. Namely, the non-arbitrage condition results in an overall lower real return to stocks and bonds, and the consequent increase in equity prices impinges on the free entry condition. At the same time, higher wages in the formal sector lower firms' profits. Total (unmeasured) output falls on impact, reflecting the large decline of informal production on impact, but quickly bounces back, driven by the expansionary effect of lower interest rates on consumption demand.

The assumption of flexible wages is a known shortcoming of the BGM model because, despite the overall expansionary effect of a monetary easing shock, the firm entry dynamics of the BGM model are at odds with the robust empirical evidence on pro-cyclical firm entry documented in the literature (Bergin and Corsetti 2008, Lewis 2009, Lewis and Poilly 2013, and Hamano and Zanetti 2022). Not surprisingly, our benchmark model suffers the same limitation. To address this shortcoming, we follow Lewis (2009) and extend the standard BGM model using two empirically motivated features, namely 1) sticky wages and 2) entry adjustment costs. The first feature is justified by the widely accepted view that wages are sticky (Erceg et al. 2000). Specifically, we assume sticky wages in the formal sector where there is product differentiation and not in the informal (flexible market) sector. Intuitively, sticky wages help keep profits high and play an economic incentive for increasing entry in response to higher demand. The second feature, entry congestion externalities, is a shorthand way to make the (formal firm) entry process sluggish. We incorporate these features into an extended version of our benchmark model.

As in Lewis (2009), sticky wages are in the form of quadratic adjustment costs a la Rotemberg, which the worker pays as an additional expenditure in her budget constraint $AC_t^w = \frac{\kappa_w}{1}(W_t^F/W_{t-1}^F - 1)^2 W_t^F/P_t$, with $\kappa_w > 0$. The corresponding (log-linearized) optimality condition for wages is given by $\hat{w}_t^F = \beta E_t\left[\hat{w}_{t+1}^F\right]\frac{\phi-1}{\kappa_w}\left(\frac{1}{\phi}\hat{l}_t^F + \hat{C}_t - \hat{w}_t^F\right)$. As in Lewis (2009) we set $\kappa_w = 77$, the same value assumed for the price stickiness constant.

The entry adjustment cost adds a congestion externality Θ to the free entry condition as follows $v_t = w_t f_{e,t} \Theta$, where $\Theta = \left(\frac{N_{E,t}}{N_{E,t-1}}\right)^{\iota}$ and $\iota > 0$. We set $\iota = 2.42$ as in Hamano and Zanetti (2022).

The blue solid lines are the responses of the extended model. Importantly, other than the pro-cyclical response of profits, firm entry and number of firms, the behaviour of the other model variables is similar to the benchmark model.

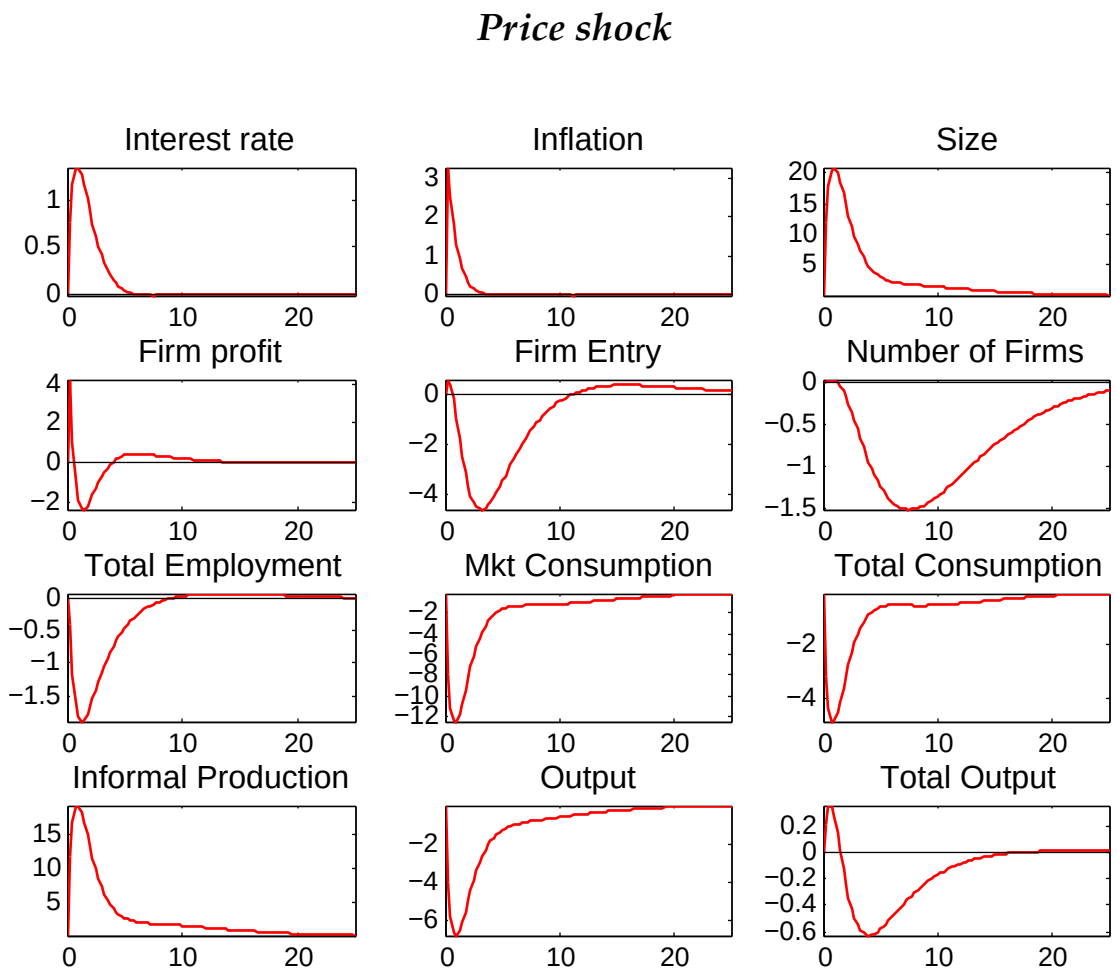

Figure 6. Impulse responses: Price shock under $i_t = 0.8i_{t-1} + 0.3E_t\pi_{t+1}$ rule in the

extended model (wage rigidity and congestion externalities.)

Last, we examine the behaviour of the extended model to a price shock that increases inflation on impact by 3 percentage points. As expected, monetary policy raises interest rates by more than 1 percentage point. As discussed earlier, the responses of all the economic variables are analogous (but of the opposite sign) to an interest rate shock. Importantly, price shocks boost the size of the informal sector and informal production but are contractionary for formal sector production and aggregate output, highlighting the buffer effect of informal production in response to adverse supply shocks.

5.2 Second moments

We now employ the extended model to perform a moment-matching exercise where we place particular interest on the (non-targeted) second moments. Table 2 shows the standard deviations and correlations of the data and the extended model.As in BGM, investment (x) in our model is represented by new firm entry to the formal sector.

Our quantitative exercise yields a few important implications. Namely, measured (formal) consumption volatility is higher than measured income volatility. This is due to the substitutability between formal and informal goods. Informal employment is more volatile than formal employment because, by assumption, the informal sector is a competitive market, whereas the formal sector is not. Third, the size of the informal sector is counter-cyclical due to the labor re-allocation effect between formal and informal sectors in response to shocks.

Standard deviations

Moment	**Data**	Model
σ_{y*}	1.57	1.57
σ_c/σ_{y*}	1.11	1.53
σ_x/σ_{y*}	1.98	1.98
σ_{l^f}/σ_{y*}	0.42	0.66
σ_{l^n}/σ_{y*}	0.53	0.75
$\sigma_{\pi*}$	0.48	0.48

Co-movements

Moment	**Data**	Model
$\rho(c,y)$	0.94	0.97
$\rho(x,y)$	0.92	0.78
$\rho(l^f,y)*$	0.76	0.41
$\rho(l^n,y)*$	-0.56	-0.68
$\rho(\pi,y)*$	-0.35	-0.45
$\rho(y,y_{-1})*$	0.92	0.82

Table 2. Second moments: Mexico. Quarterly frequency, lower case variables denote cyclical component (*Data moments from Alberola & Urrutia, 2020.)

5.3 Is informality stabilizing?

We finally proceed to examine the implications of firm entry and informality in terms of the costs of disinflation, as done by Alberola & Urrutia(2020). Table 3 summarizes the cumulative one-year impact of a one standard deviation interest rate shock under two model specifications, namely the extended informality model (*Full model*) and the extended model without an informal sector (*No informality*), the latter also calibrated to match the same subset (formal sector) of target moments in the data.

Monetary policy tightening		
Cumulative 1^{st} *year effect*	*Full model*	*No informality*
Measured output	-0.88	-1.26
CPI inflation	-0.11	-0.11
Interest rate	0.24	0.24
Sacrifice ratio	8.14	11.09
Formal consumption	-1.52	-1.17
Formal employment	-1.07	-0.95
Total consumption	-0.46	–
Total employment	-0.44	–

Table 3. Informality and the costs of disinflation.

The key result from the firm dynamics model is that a similar reduction of inflation in an economy with an informal sector is associated with a smaller decline in output compared to a parallel economy without informality. Specifically, the model with informality implies a sacrifice ratio of 8.14, less than three-fourths the size of the sacrifice ratio in a similar economic environment but without an informal sector ($\mathtt{sr}$ = 11.09). Our finding is consistent with the widely accepted view that informality provides additional economic consumption insurance by acting as an *employment buffer* (Ulyssea 2020). A further examination of Table 3 provides the intuition behind this result. Although a monetary tightening is more contractionary on formal consumption and formal employment in the full model, the size of the informal sector increases during the downturn along with the household's decision to substitute consumption from relatively expensive formal goods toward the relatively inexpensive informal good. As a result, *total* consumption and *total* employment fall by less than half of their predicted fall under the model without informality.

Notably, our finding that informality is stabilizing for inflation is in stark contrast to the counter-intuitive prediction of the model in Alberola & Urrutia (2020), which yields the

opposite prediction, namely that the sacrifice ratio is larger in an economy with an informal sector. As such, our results underline the crucial role of the counter-cyclical adjustment of informality for quantifying the effect of monetary policy shocks in economies with a large informal sector.

5.4 Robustness

We now examine the sensitivity of our theoretical results to key model parameters. In particular, we are interested in 1) the elasticity of labor supply, 2) the level of price and wage stickiness, and 3) the degree of substitutability between formal and informal goods.

Table 4 summarizes the sensitivity of the model's implications concerning price stickiness and labor supply. Specifically, in columns 2 and 3, we consider more price flexibility by setting the value of the price and wage adjustment parameters to $\kappa_i = 35$, which is about half of the benchmark model analogue. In columns 4 and 5, we assume that labor supply is inelastic (as opposed to elastic in the benchmark model) by setting the inverse Frisch elasticity parameter to $\phi = 2$.

Our benchmark model implications are robust to the sensitivity results from Table 2, with some quantitative differences. Namely, with more price flexibility, the difference in sacrifice ratios between models with and without informality decreases. However, with more inelastic labor supply, the difference in sacrifice ratios is amplified relative to the benchmark model, implying an even more prominent stabilizing role of informality.

	More price flexibility		*Inelastic labor*	
Cumulative 1^{st} *year effect*	*Full model*	*No informality*	*Full model*	*No informality*
Measured output	-0.73	-0.978	-0.95	-1.58
CPI inflation	-0.2	-0.2	-0.09	-1.09
Interest rate	0.2	0.2	0.24	0.24
Sacrifice ratio	3.67	4.75	10.35	17.42
Formal consumption	-1.29	-1.00	-1.49	-1.23
Formal employment	-0.8	-0.63	-1.17	-1.41
Total consumption	-0.32	–	-0.65	–
Total employment	-0.42	–	-0.63	–

Table 4. Sensitivity to price flexibility and (inelastic) labor supply.

Last, we examine robustness to higher substitutability between formal and informal goods. To this end, we consider values of the constant elasticity of substitution between formal and informal goods that imply larger substitutability than we assumed in the benchmark model. We employ two values of the elasticity parameter used in the literature. In one simulation, we set $\theta = 4$ as in Yépez (2019), and in the other simulation, we set $\theta = 8$ as in Fernandez & Meza (2015) and Alberola & Urrutia (2020).

Cumulative 1st *year effect*	*No informality*	$\theta = 4$ *model*	$\theta = 8$ *model*
Measured output	-1.26	-1.24	-1.41
CPI inflation	-0.11	-0.1	-0.09
Interest rate	0.24	0.24	0.25
Sacrifice ratio	11.09	12.44	16.21
Formal consumption	-1.17	-2.34	-3.01
Formal employment	-0.95	-1.87	-2.54
Total consumption	–	-0.79	-0.96
Total employment	–	-0.24	0.06

Table 5. Sensitivity to higher substitutability between formal and informal goods.

Table 5 summarizes the sensitivity results. The model implies that as the substitutability between formal and informal goods increases, the cost of disinflation measured by the sacrifice ratio also increases, and importantly, it can be greater than under an economy without informality. Intuitively, when it is easier to substitute consumption from formal to informal goods, then formal output becomes more volatile for a given shock. Most importantly, our quantitative exercise indicates that the stabilizing effect of informality on inflation crucially depends on the elasticity of substitution between formal and informal goods. The values assumed for this elasticity in the extant literature vary widely (ranging from 1.5 to 8). Despite the lack of precise estimates of this elasticity, our view is that it is sensible to assume (as we do in our model) that, in practice, the degree of substitutability between goods is not very large because the available varieties of informal goods (usually retail and low-skilled services) are likely to be much less than the available varieties formal goods in the economy. Given our calibration, our quantitative results suggest that informality *facilitates* inflation stability. Importantly, our empirical evidence and quantitative results are in stark contrast and qualify, respectively, the findings in the quantitative model of Alberola and Urrutia (2020).

6 Conclusion

The aftermath of the COVID-19 pandemic and its attendant impact on supply chains brought back the spectre of high inflation to the forefront of the global policy debate. The public widely experiences inflation as a regressive tax, usually with a more considerable negative impact on poorer households' welfare. Central banks in emerging markets were ahead of the curve relative to the major central banks in high-income countries in tightening monetary policy in response to rising inflation. However, it was not clear by the beginning of the tightening cycle whether or not the timing and magnitude of interest rate rises by central banks in emerging economies was premature.

Our paper contributes to this ongoing debate in two ways. First, we document empirically that the size of the informal sector increases when monetary conditions are tightened. Second, we employ a general equilibrium firm dynamics model to theoretically show that, given a sensible parametrization for the elasticity of substitution between formal and informal goods, monetary policy facilitates inflation stability. While formal firms' profitability is directly affected by financial conditions, informal production is inherently less sensitive to interest rates. Furthermore, due to nominal rigidities in the formal sector, monetary policy surprises are absorbed on impact by the flexible informal sector due to the expenditure-switching effect, and the latter sector effectively works as a buffer against monetary policy surprises. As a result, the cost of disinflation is *lower* in economies that feature a large informal sector.

The findings of this study underscore the need to develop further empirical work on two fronts. First, the collection and use of micro-level datasets on firm-level entry and exit over the business cycle, along with product creation for middle- and low-income countries. Second, given such data, empirically estimate the relevant elasticities and quantify the magnitude and importance of the aggregate impact of firm-level and product creation margins on misallocation, aggregate productivity, inflation, and output in these countries.

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