Firm Dynamics, Inflation, and the Transmission of Monetary Policy

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Abstract

I study how firm dynamics affect inflation and the transmission of monetary policy in a New Keyensian model with endogenous business formation and destruction. The model matches facts about the relative size of entrants and exiters. I first show that a shock directly to the cost of entry or the fixed cost of production that leads the mass of producers to fall generates an increase in inflation and a drop in aggregate labor productivity. This mechanism may help explain the relatively muted disinflation that the U.S. experienced during the Great Recession. I then provide novel evidence that firm dynamics respond to monetary policy shocks, and I calibrate the model so that it matches that evidence. I show that endogenous fluctuations in entry generate an intertemporal trade-off in monetary policy; a contractionary policy shock leads employment and inflation to decline on impact, but these variables later overshoot, as the shock also leads entry to decline and exit to rise.

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1 Introduction

What role do firm dynamics play in the business cycle? Firm dynamics are a natural channel through which one might expect monetary policy and exogenous shocks to affect the economy; the decision to create a new business or exit a market is inherently forward-looking and is affected by financing constraints, interest rates, and demand. Moreover, new businesses are an important source of employment growth. In this paper, I study business cycles in a novel quantitative New Keynsian model featuring endogenous entry and exit, heterogeneous firms, and a producer lifecycle. I calibrate the model to match new evidence on the response of business formation and destruction to surprise monetary policy shocks.

Using the model, I show that firm dynamics play a meaningful role in business cycles. I first show that a shock that reduces the mass of producers directly through entry or exit leads inflation to rise and average labor productivity to fall. A decline in the mass of producers of the magnitude that the U.S. experienced during the Great Recession leads inflation to rise by over half a percentage point and average labor productivity to fall by 2 percent. I also show that endogenous fluctuations in firm dynamics affect how monetary policy works. In this model, a contractionary shock leads inflation to decline in the near-term but rise over the medium term, as productive capacity endogenously declines. The shock also leads average labor productivity to decline as the remaining producers increase output at a lower marginal product.

This is not the first paper to study the role of firm dynamics in the business cycle in a structural New Keynesian model. (See, e.g., Bilbiie, Ghironi and Melitz, 2008; Bergin and Corsetti, 2008, and others) However, past studies assume that all firms are identical, including entrants. As Gamber (2023) shows, this assumption is both at odds with the data and greatly affects the role of entry in the transmission of TFP shocks in an RBC model. (See also Midrigan, 2008) Moreover, these studies ignore endogenous fluctuations in exit. This paper's findings, which incorporate heterogeneity, differ both qualitatively and quantitatively from earlier work.

I begin by presenting a New Keynesian model featuring sticky prices and wages, heterogeneous firms, and endogenous entry and exit. A key simplifying assumption in the model is that production is divided into two sectors: an intermediate sector featuring heterogeneous firms, free entry, and endogenous exit, and a retail sector, whose firms purchase a bundle of intermediates that they convert to retail goods and sell to consumers. The retail sector's firms face sticky prices, generating a new keynesian phillips curve, and wages are sticky. There is a monetary authority who sets the nominal interest rate according to a Taylor rule.

To quantify the sensitivity of firm dynamics to aggregate conditions in the model, I estimate how firm dynamics respond to exogenous monetary policy shocks in data. Using quarterly data from the Census Bureau's Business Employment Dynamics (BED) database, I estimate the response of the number of existing establishments, establishment birth and death, and job creation and destruction due to establishment births and deaths to externally-identified monetary policy shocks. Following Ramey (2016), I estimate a local projection of these measures of firm dynamics on identified monetary policy shocks. In the baseline specification, I use the shocks from Bauer and Swanson (2022), who identify the effects of monetary policy using high-frequency changes in interest rate futures around FOMC announcements.

I find that a monetary tightening leads the mass of establishments to decline meaningfully and persistently. A 100bps shock leads the stock of establishments to decline by over 2.5 percent after 20 months, and this effect only gradually dies out. These effects are generated both by a spike in exits and a persistent decline in entry. These results use a new methodology to complement evidence from Bergin and Corsetti (2008), who find that entry declines following a monetary tightening in a VAR.

Firm dynamics play a meaningful role in the business cycle in this model. I first study a surprise increase in the cost of entry, assuming a monetary policy rule that keeps the real interest rate fixed. The shock leads the mass of operating producers to fall. Because the interest rate is fixed, demand is unchanged, and the smaller mass of producers must increase their output to meet this demand. Because their production functions feature decreasing returns, in order to induce them to increase their output at a lower marginal product, the price must rise. Average labor productivity also falls, as these producers need more labor to produce the same amount of output because they face decreasing returns. I show that this mechanism could help account for the "missing disinflation" during the Great Recession.

I then examine how endogenous firm dynamics affect the transmission of a monetary policy shock in the model. In a version of the model in which the central bank follows a Taylor rule, a shock that leads the federal funds rate to increase by 1 percentage point leads the number of businesses to decline, falling by 2.6 percent after 6 quarters—about as much as in the data. The stock of businesses only slowly returns back to its original level. Although this contractionary shock leads inflation and employment to fall on impact, they eventually overshoot, as demand recovers faster than the number of operating producers. While the shock leads inflation to decline 0.4 percentage point on impact, inflation overshoots persistently thereafter—by nearly 0.2 percentage point at its peak, presenting an intertemporal tradeoff for monetary policy.

1.1 Existing literature

An existing literature studies the role of entry and exit in models with homogeneous firms. (See, for example, Bilbiie, Ghironi and Melitz (2008), Bergin and Corsetti (2008), Bilbiie, Fujiwara and Ghironi (2014), and Bilbiie and Melitz (2020)) The models in these papers face two shortcomings. First, the assumption of homogeneity, which allows them to achieve tractability, is clearly at odds with the data; entering producers are meaningfully smaller than incumbents. (Midrigan, 2008) And second, these papers assume that exit is exogenous, and so it does not fluctuate endogenously with aggregate conditions. I show in this paper that this assumption is at odds with the data, and I incorporate endogenous exit into the model. Because producers are heterogeneous and there is a producer lifecycle in my model, fluctuations in firm dynamics have persistent and long-lasting effects on real outcomes.

This paper also provides new evidence on the response of firm dynamics to monetary shocks. Bergin and Corsetti (2008) estimates a VAR including industrial production, CPI, commodity prices, the nonborrowed reserves ratio, and net business formation (or new incorporations). I find similar results for net business formation and new incorporations, but my framework also allows me to study business destruction, as well as the employment effects of business formation and destruction.

This paper builds on recent work studying real business cycle models with endogenous firm dynamics and producer heterogeneity. (Gamber, 2023 and Clementi and Palazzo, 2016). These previous papers study models without nominal rigidities, and so did not explore the effects of firm dynamics on inflation or monetary policy. This paper embeds these RBC frameworks into a New Keynesian model, leveraging recent advances in solution techniques to achieve tractability. (Auclert et al., 2021)

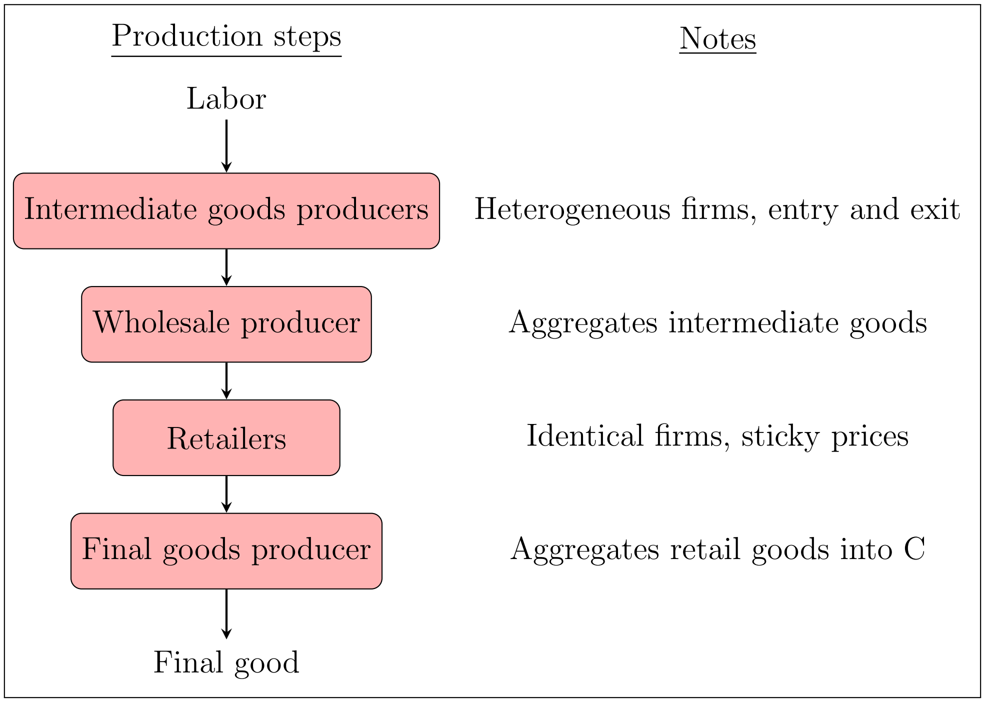
Lastly, this paper also relates to recent work on the supply-side effects of monetary policy, including Baqaee, Farhi and Sangani (2024) and Graves, Huckfeldt and Swanson (2023). Relative to those papers, I study a different channel through which monetary policy affects the productive capacity of the economy: business formation and destruction.

2 A New Keynesian model with firm dynamics

I embed a sector with heterogeneous producers and endogenous entry and exit into an otherwise-standard New Keynesian framework. As in the standard New Keynesian model, there is a representative household who consumes the final good, saves in a risk-free asset, and supplies labor. There is a monetary authority who sets the nominal interest rate according to a Taylor rule. There are two sources of nominal rigidities: sticky prices and sticky wages.

The primary point of departure from the textbook New Keynesian model is in the production structure of the economy, which is outlined in figure 1. There is an intermediate

Figure 1: Production structure in the model



goods sector comprising a continuum of heterogeneous producers, each of which uses labor as its sole input. This sector resembles the model in Hopenhayn and Rogerson (1993) – producers face labor adjustment costs, heterogeneous stochastic TFP, and a random fixed cost of production. There is free entry in this sector.

There is also a wholesale sector, which purchases the output of the intermediate goods sector and converts it into a wholesale good. This sector is perfectly competitive. The remainder of the production structure is similar to the textbook New Keynesian model: In the retail sector, a continuum of identical firms each uses the wholesale good to produce a differentiated retail good, which it sells to the final goods producer. Retail firms face sticky prices à la Rotemberg (1982), and this sector generates a Phillips Curve. Lastly, a perfectly competitive final goods producer uses a CES production function to assemble the final good, which it sells to the representative household.

2.1 Representative household

There is a representative household who chooses state-contingent paths for consumption and hours worked to maximize the discounted sum of future utility. I assume that its utility function is separable across time and between labor and consumption:

$$\max_{C_t, N_t} \sum_{t=0}^{\infty} \beta^t u(C_t) - v(N_t) \tag{2.1}$$

I specify the following functional forms for the felicity function:

$$u(C) = \frac{C^{1-\varrho}}{1-\varrho}, \quad v(N) = \varphi \frac{N^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \tag{2.2}$$

where ν is the Frisch elasticity of labor supply, φ is a scaling parameter that determines the disutility of labor, and ρ is the coefficient of relative risk aversion. A necessary first order condition of solution to the household's problem is the Euler equation

$$C_t^{-\varrho} = \beta R_t C_{t+1}^{-\varrho}. \tag{2.3}$$

2.2 Wage-setting

The household supplies a continuum of differentiated varieties of labor. A representative firm buys these differentiated labor services and turns them into aggregate labor services L_t using a CES production function. The nominal wage for each variety is set by a labor union whose objective is to maximize the value of the representative household. These unions take as given the consumption-saving decision of the household, as well as the labor demand schedule of the labor bundling firm. There is a quadratic Rotemberg (1982) adjustment cost specified in utils of adjusting nominal wages. This setup is a relatively standard way to incorporate sticky wages into a model and generates a wage Phillips Curve:

$$\pi_t^w(\pi_t^w - 1) = \kappa_w\left(\frac{v'(N_t)}{u'(C_t)} - 1\right) + \beta_t\mathbb{E}_t[\pi_{t+1}^w(\pi_{t+1}^w - 1)], \tag{2.4}$$

where κ_w is the slope of the wage Phillips Curve.

2.3 Intermediate goods sector

There is a sector comprising a variable measure N_t of intermediate goods producers, each indexed by $i \in [0, N_t]$. Producers hire labor ℓ_{it} in a Walrasian market, taking the real wage W_t as given. They choose their real price ρ_{it}, taking as given their demand schedule $x_{it} = d(\rho_{it}; S)$, where S denotes the aggregate states in the economy. As in Hopenhayn and Rogerson (1993), these producers face labor adjustment costs and a fixed cost of production, and there is endogenous exit and free entry.

Timing within each period works as follows:

1. Producers who operated in the previous period enter the period, having employed ℓ workers last period. Denote by z its productivity from the previous period.

2. Each incumbent producer draws an iid fixed cost $c_F \sim G(c_F)$. It then decides whether to pay the fixed cost and continue producing or to exit. The value of exit is normalized to 0.

3. New entrants then enter the economy, choose employment, output, and prices and receive the profits. They pay no initial employment adjustment cost.

4. Continuing incumbents observe their current draw of productivity z' $F(z'|z)$. All firms decide how much to produce and what price to set.

Turning to the recursive formulation of the firm's problem: The value of a producer who employed ℓ workers last period and had productivity z last period who has drawn fixed cost c_F is:

$$\tilde{V}(z,\ell;c_F) = \max\left\{0, \int V(z',\ell)dF(z'|z) - c_F\right\}, \tag{2.5}$$

where the continuation value V is given by:

$$V(z,\ell) = \max_{\rho,\ell'} \rho x - w\ell' - \phi(\ell,\ell') + \frac{1}{1+r}\int \tilde{V}(z,\ell;c_F)dG(c_F) \tag{2.6}$$

and the firm's choice of output, price, and employment must satisfy both the production function and demand curves:

$$x = F(z,\ell) \tag{2.7}$$

$$x = d(\rho;S) \tag{2.8}$$

Production function. The production function is below, where $\vartheta \in (0,1)$ is the span-of-control parameter and z is idiosyncratic TFP:

$$F(z,\ell) = z\ell^{\vartheta} \tag{2.9}$$

Free entry. Each period, a mass m_t of new producers enters the economy. The mass of entrants is endogenous. There is an unlimited mass of potential entrants, each of whom observes the aggregate state of the economy and the cost of entry c^E before deciding whether or not to enter. If a potential entrant decides to enter, they pay the sunk cost, draw an initial value of $z \sim H(z)$, and then choose their initial employment freely.

They will only enter if the expected value of entry exceeds the cost of entry. In equilibrium, the value of entry will be such that $c_E = V^E$, and potential entrants will be indifferent between entering or not.

$$c_E \leqslant V^E \equiv \int \max_{\ell} V(z,\ell)dH(z) \tag{2.10}$$

2.4 Wholesale sector

A perfectly competitive wholesaler purchases the output of the intermediate producers, bundles it into a wholesale good, and sells the wholesale good to retailers.

Wholesale production function. In the baseline version of the model, the wholesaler production function takes the following form:

$$X = \int x d\Lambda \tag{2.11}$$

In this case, the demand for each variety is perfectly elastic at the prevailing price $\bar{\rho}_t$.

2.5 Retail sector

In the last step of the production block, there is a unit mass of identical retailers who purchase the wholesale good M at real price ρ and use it to produce differentiated retail goods. These retail firms face CES demand with elasticity ϵ_p and their production function is given by

$$y = F(X) \equiv \Theta X^{\alpha}, \tag{2.12}$$

where α is the span of control for the retailers, and Θ is their total factor productivity. These producers face a quadratic adjustment cost, as in Rotemberg (1982). Assuming a symmetric equilibrium in which all retailers have the same TFP and set the same price, the solution to their problem can be summarized by the following three equations:

1. Materials demand. Denote the marginal cost of the retailer by mc_t.

$$mc_t = \frac{\rho_t}{F_X(X_t)} \tag{2.13}$$

2. Phillips Curve. Denote gross price inflation by π_t, the slope of the Phillips Curve by

κ_p, and R_t the gross real interest rate.

$$\pi_t(\pi_t - 1) = \kappa_p\left(\frac{\epsilon_p}{\epsilon_p - 1}mc_t - 1\right) + \mathbb{E}\left[\frac{\pi_{t+1}(\pi_{t+1} - 1)}{R_t}\frac{Y_{t+1}}{Y_t}\right] \tag{2.14}$$

3. Production function

$$Y_t = F(X_t) = \Theta X_t^{\alpha} \tag{2.15}$$

2.6 Monetary authority

There is a central bank that sets the nominal interest rate according to the following Taylor rule:

$$i_t = r^* + \phi\pi_t + \epsilon_t^m \tag{2.16}$$

where r^* is the natural rate of interest and ϵ_t^m is a monetary shock. The forward-looking real interest rate is defined as below.

$$R_t = \frac{1 + i_t}{1 + \pi_{t+1}} \tag{2.17}$$

2.7 Equilibrium

Given a sequence of shocks $\{\epsilon_t^m\}$ an equilibrium is a set of sequences for wages, inflation, the real price of the intermediate good, the mass of entrants, and the nominal interest rate, $\{W_t, \pi_t, \rho_t, m_t, i_t\}$ such that

1. The new keyensian phillips curve and the wage phillips curve both hold

2. The market for the intermediate good clears

3. The free entry condition holds

4. The household's Euler equation holds
5. The nominal interest rate obeys the Taylor rule

3 Steady state

3.1 Calibration of intermediate sector

Wholesale production function. In the baseline version of the model, I assume that the wholesale production function is additive, leading to perfect competition in the intermediate goods market.

Intermediate sector. I choose the steady state sunk cost of entry to match the average size of an establishment as reported in the 2007 BDS.[1] Entering producers draw their initial productivity value from a shifted version of the stationary distribution implied by the law of motion for incumbent productivity, $\mathcal{H}(log(z))$. In particular, entering producers draw their initial value of log productivity from the distribution $H(log(z)) = \mathcal{H}(log(z) + d_E)$. I choose the parameter d_E to match the average employment of entering establishments relative to the overall average in the BDS.

I assume that the fixed cost of production is log-normally distributed, with parameters μ_F and σ_F. I choose μ_F to match the exit rate, which equals the entry rate in steady state, and σ_F to target the average size of exiting establishments. A higher value of σ_F leads exit to be more random, increasing the average size of exiters.

Firm-level TFP follows an AR(1) process, with autocorrelation ρ_z and innovation dispersion σ_z. I set $\rho_z = 0.85$ and $\sigma_z = 0.15$, equal to their values in Gamber (2023). I set the span-of-control parameter, which determines the labor share, equal to $\vartheta = 0.6$.

I impose a quadratic form for the labor adjustment cost: $\phi(\ell, \ell') = \phi_\ell(\ell' - (1-\delta)\ell)^2$.

[1] Equivalently, I could choose the wage to match the average size of an establishment. The cost of entry is then chosen to equal the expected value of entry.

Table 1: Calibration targets and model fit

Moment	Target	Model	Source
Avg. emp. of continuing producers	17.31	17.56	BDS, 2007
Entry rate	11.75%	11.64%	BDS 2007
Avg. emp. entrants	7.87	7.75	BDS, 2007
Avg. emp. exiters	8.10	8.51	BED/BDS, 2007
Autocorr. of log emp. growth	0.13	0.13	Gamber (2023)

Table 2: Calibrated parameters

Parameter	Description	Value
c_E	Sunk entry cost	7.41
μ_F	Mean of log fixed cost	-0.68
σ_F	Std. Dev. of log fixed cost	2.50
ϕ_ℓ	Labor adj. cost	0.012
d_E	TFP disadvantage of entrants	0.63

The parameters ϕ_ℓ and δ denote the size of the adjustment cost and the exogenous annual separation rate, which I set to 0.19. The size of the adjustment cost is determined by the parameter ϕ_ℓ. Following Gamber (2023), I choose ϕ_ℓ to target the autocorrelation of log employment growth.

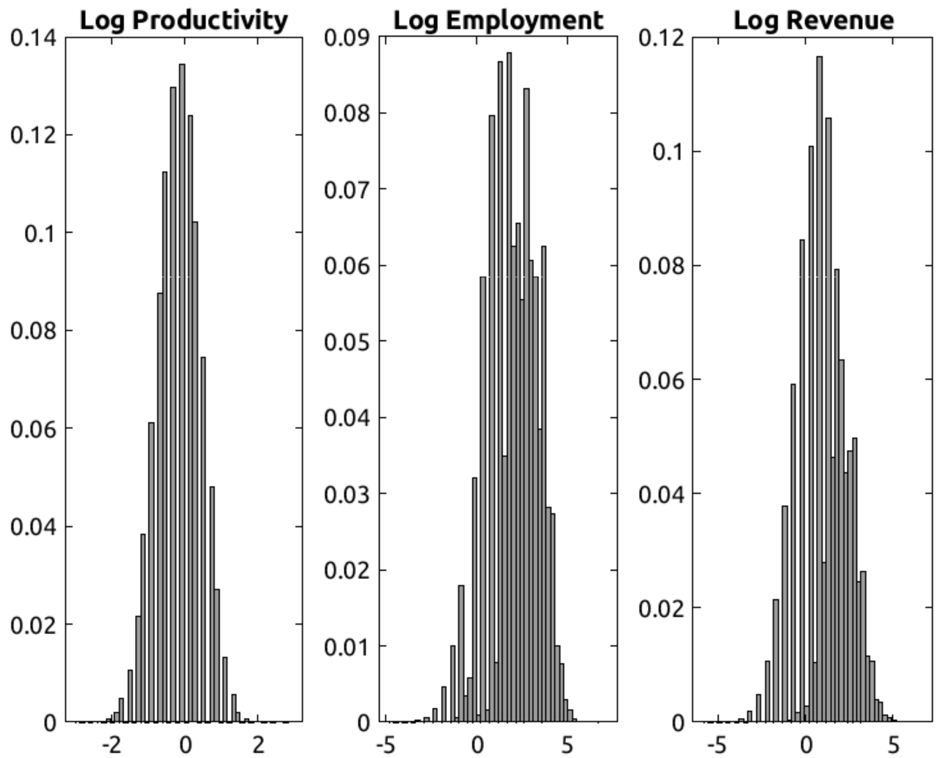
Calibration targets and parameter values. Table 1 describes the targeted moments and model fit, and 2 summarizes the calibrated parameters in the model. The model matches targeted moments well.

3.2 Remaining calibration

Phillips curve slopes. Following Bardóczy and Velásquez-Giraldo (2024), who also calibrate an annual model with sticky prices and wages, I set the slope of the price Phillips curve to be $\kappa_p = 0.24$ and the slope of the wage Phillips curve to be $\kappa_w = 0.03$.

Taylor rule. The coefficient on inflation in the Taylor rule is $\phi = 1.5$, a standard value.

Figure 2: Distribution of selected producer-level variables



Note: Each panel shows a histogram of a simulated producer-level variable in steady state. Source: Author's calculations.

Household preferences. The Frisch elasticity of labor supply is 0.5 and the coefficient of relative risk aversion ins 2. I choose the disutility of labor φ so that $v'(N) = u'(C)$ in steady state.

3.3 Firm heterogeneity

Figure 2 shows the distribution of firm-level productivity, employment, revenue, and value. Productivity, shown in the top-left panel, has a long right tail and a positive mode, reflecting both the log-normal stationary distribution of the firm-level productivity process, as well as the endogenous exit choice. The remaining variables all inherit the long right tails from the productivity process.

Figure 3: Firm lifecycle in the model

Note: Each panel shows the average of a simulated producer-level variable conditional on producer age. Points marked with an "x" show the same moments from the Census Bureau's Business Dynamics Dataset, 2007. Source: Author's calculations and U.S. Census Bureau.

3.4 Firm lifecycle

Figure 3 shows the lifecycle of three producer-level variables in the model. The exit rate declines over the producer lifecycle, as producers' productivity grows and they are farther from the exit threshold. Average productivity rises over the lifecycle, reflecting reversion to the mean for the younger producers, as well as a selection effect—low productivity producers are more likely to exit, driving up the average productivity of the remaining producers in each cohort. Lastly, producer size grows with age, reflecting this rising productivity. The model fits data from the BDS on the lifecycle of employment well for the first decade or so, but employment in the model continues growing more quickly than it does in the data.

4 Empirical framework and results

Key to assessing the role of business formation and destruction in the transmission of monetary policy is an estimate of the elasticity of these quantities to monetary policy. In this section, I present novel evidence on the effects of exogenous fluctuations in interest rates on firm dynamics.

4.1 Data on firm dynamics

For a quarterly measure of firm dynamics, I use data from the Census Bureau's Business Employment Dynamics (BED) database. From the BED, I extract quarterly series for establishment births and deaths. The BED does not report the level of establishments, so I construct a series for the level by cumulating net births over time, using the Quarterly Census of Employment and Wages number of establishments in 1993Q1 as the initial condition. I exclude the pandemic period, so the time series for these variables runs from 1993:Q1 – 2019:Q4. For my main regressions, I interpolate the quarterly data linearly to get a monthly series.[2]

Figure 4 depicts these series. Panel 4a shows the establishment count. As discussed in Gamber (2023), the number of establishments declined following the Great Recession and did not return back to trend. Panel 4b shows establishment births and deaths. There is a significant amount of churn in establishments, with between 2 and 3 percent of establishments being destroyed and replaced with new establishments each quarter.

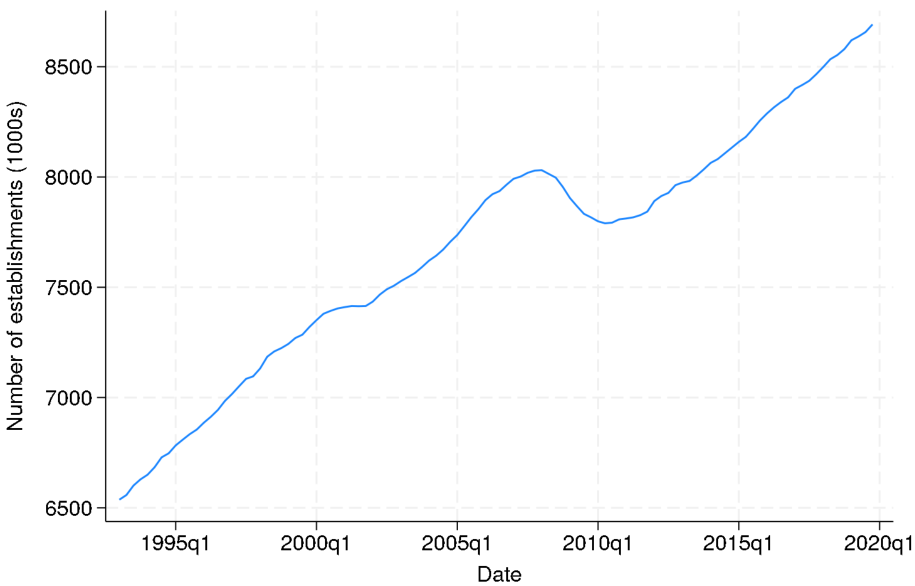
4.2 Data on monetary shocks

As a measure of exogenous fluctuations in monetary policy, I use shocks from Bauer and Swanson (2022). These shocks are identified from high-frequency movements in Eurodollar futures around monetary policy announcements, orthogonalized with respect to macroeco-

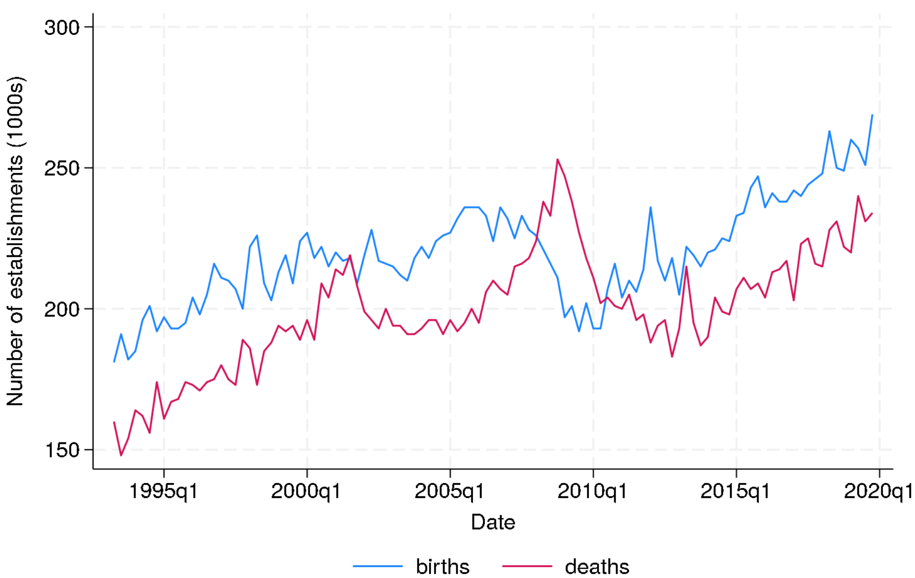
[2] I obtain similar results using un-interpolated results, where I aggregate the monthly monetary shocks to a quarterly frequency by summing.

Figure 4: Firm dynamics in the BED

(a) Establishment count



(b) Establishment births and deaths



Note: Each panel shows the time series of a variable used in the analysis in this paper.
Source: U.S. Bureau of Labor Statistics BED and QCEW data. Author's calculations.

nomic and financial variables. I sum these shocks within each quarter to obtain a quarterly measure of exogenous monetary shocks.[3]

4.3 Empirical framework

Following Ramey (2016), I estimate the following local projection model:

$$y_{t+h} = \alpha_h + \beta_h \epsilon_t + \sum_{\ell=1}^{L} \gamma_{h,\ell} X_{t-\ell} + \delta_h t + \eta_{t,h} \tag{4.1}$$

where y_t is the outcome variable of interest, ϵ_t is the shock, and X_t are controls. As discussed in Ramey (2016), because the shock is orthogonalized with respect to macroeconomic and financial variables, the only controls needed in X_t are lags of the outcome y_t and of the shock ϵ_t. Given the meaningful structural breaks around the Great Recession in business dynamism, I also include an indicator variable for whether the observation is post- or pre-2008. The parameters of interest are $\hat{\beta}_h$, which trace out the impulse response of the shock ϵ_t on the outcome variable y_t at horizon h. I report these estimates with Newey and West (1987) robust standard errors.

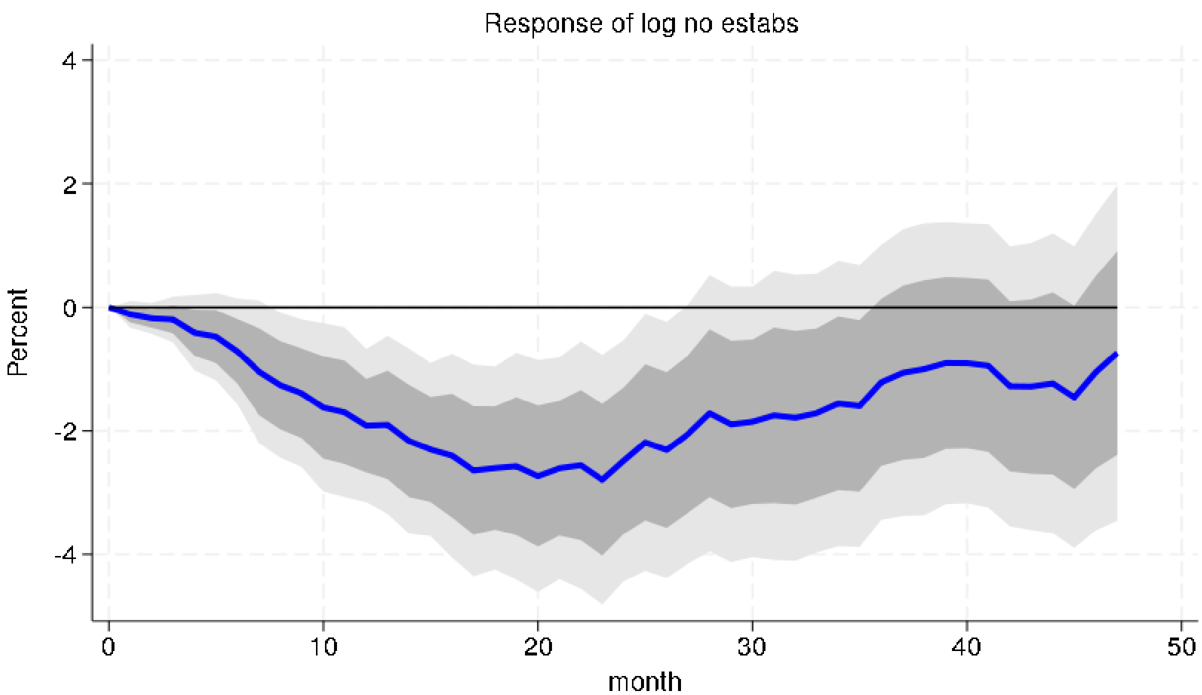
4.4 Results

Fact 1: Surprise increases in the federal funds rate persistently reduce the number of establishments. Figure 5 depicts the response of the log number of establishments to the shock. As it shows, a surprise increase in the federal funds rate of 1 percentage point leads to an approximately 2.6 percent decline in the number of establishments after around 6 quarters. The effect of the shock is persistent, and the number of establishments only begins to recover after 2 years.

Fact 2: Both entry and exit account for the decline in the number of establishments. The number of establishments can decline either because entry falls or exit

[3] I rescale these shocks so the effect on the federal funds rate on impact is one.

Figure 5: The effect of a monetary policy shock on the log number of establishments



Note: This figure shows the dynamic effect of a 100bps contractionary shock to the federal funds rate on the log number of establishments. Source: U.S. Bureau of Labor Statistics BED and QCEW data and Bauer and Swanson (2022) shocks. Author's calculations. Reported error bands show 68 percent and 90 percent confidence intervals.

rises. To investigate which of these margins responds to monetary policy, I estimate the local projection of the number of log establishment births and deaths on the shock. Figure 6 depicts these responses. As the figure shows, establishment formation declines and and establishment destruction rises following the shock, with both margins contributing to the initial decline in the number of establishments. The establishment formation margin's response is more persistent and less noisy than the establishment destruction's margin. In summary, monetary shocks reduce the number of establishments, acting through both the entry and exit margin.

4.5 Calibrating responsiveness of firm dynamics in the model

Entry margin. To match the empirical response of entry to a surprise increase in the nominal interest rate in the model, I specify the following relationship between the cost of entry and the mass of entrants:

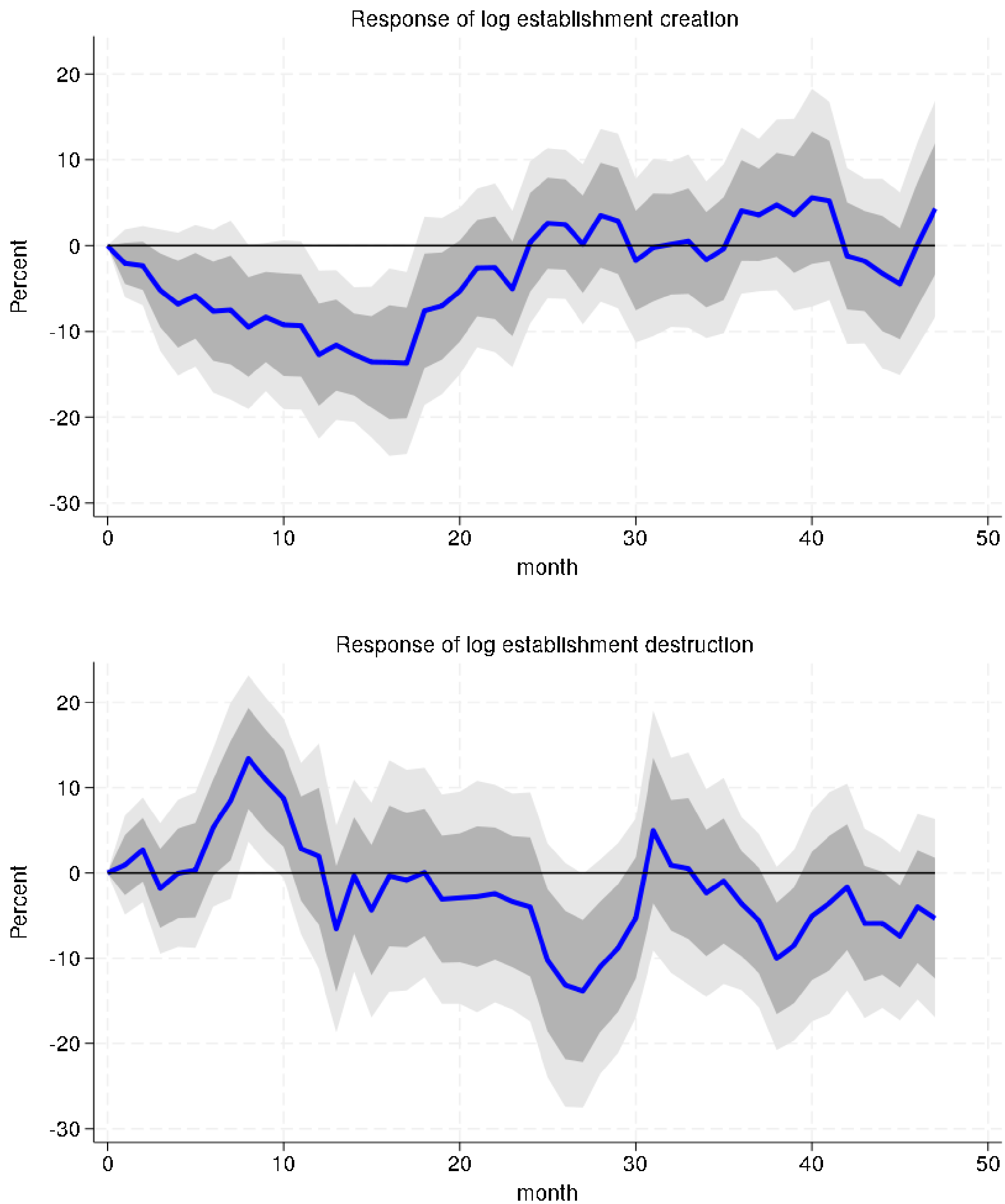
$$c_E = \bar{c}_E \left(\frac{m_t}{\bar{m}} \right)^{\epsilon_E} \tag{4.2}$$

where $\bar{c}_E$ is the steady-state entry cost and $\bar{m}$ is the steady state mass of entrants. The parameter ϵ_{c_E} governs the elasticity of the cost of entry to the number of entrants. As in Gamber (2023) and Gutiérrez, Jones and Philippon (2021), when $\epsilon_E > 0$, the cost of entry rises with the number of entrants, dampening fluctuations in entry.

This specification can be thought of as a reduced-form for congestion effects—the more new establishments there are in a given period, the higher the cost is as they compete for the same financing or inputs. For the purposes of calibration, I can select the value of ϵ_E that delivers an impulse response of business formation to a monetary shock that matches the one in the data. I select a value of 4.

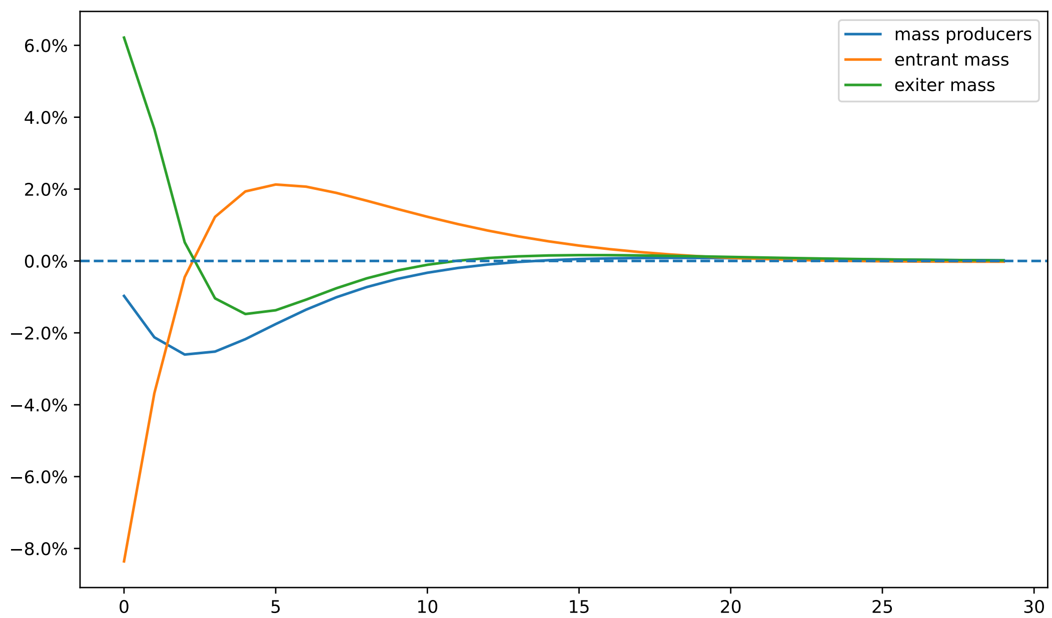
Exit margin. Similarly, I allow the fixed cost of production to fluctuate with the real interest rate in order to target the empirical response of exit to a monetary shock:

Figure 6: The entry and exit margin response to the monetary policy shock



Note: These figures show the dynamic effect of a 100bps contractionary shock to the federal funds rate on the log number of establishment births and deaths. Source: U.S. Bureau of Labor Statistics BED and QCEW data and Bauer and Swanson (2022) shocks. Author's calculations. Reported error bands show 68 percent and 90 percent confidence intervals.

Figure 7: Firm dynamics in the model following a monetary shock



Note: This figure show the dynamic effect of a 100bps contractionary shock to the federal funds rate on the log number of establishments, births, and deaths in the model. Source: Author's calculations.

$$c_F = \bar{c}_F \left(r_t - \bar{r} \right)^{\epsilon_F} \tag{4.3}$$

where $\bar{c}_F$ and $\bar{r}$ are the steady-state values of the fixed cost of adjustment and the real interest rate, respectively. The parameter ϵ_F governs the extent to which the fixed cost of production varies with the real interest rate. In practice, $\epsilon_F > 0$, and so the fixed cost will increase with the real interest rate, consistent with a working capital channel. I select a value of 11.

Figure 7 shows the response of three measures of firm dynamics in the model following the shock. As it shows, the mass of entrants falls roughly 8 percent on impact, while the mass of exiting producers rises by about 6 percent. These movements generate a decline in the mass of producers of 2.6 percent, in line with the data.

5 Firm dynamics and monetary policy

With a model that is calibrated to match the cross-sectional distribution of business characteristics, as well as the time series behavior of firm dynamics following a surprise monetary tightening, I now turn to the central question of the paper: What is the role of firm dynamics in the propagation of monetary policy? To answer this question, I study the response of the economy to different shocks.

5.1 Firm dynamics and inflation

To first understand the effects of fluctuations in the number of producers on macroeconomic aggregates, I study a shock to the cost of entry.[4] The size of the shock is chosen to roughly match the decline in the mass of firms relative to trend in the US during the Great Recession. To isolate the effects of this shock, I fix the real interest rate at its steady state value. This choice isolates the effects of the decline in entry on inflation and neutralizes the endogenous response of monetary policy.[5] (In the following section, I study an economy with a Taylor rule.)

Figure 8 shows the response of inflation and selected other variables to a shock to the cost of entry. The entry rate declines and recovers, with some slight overshooting. The size of the shock was chosen so that the mass of producers falls by a bit over 7 percent, the amount by which the number of establishments per capita fell during the Great Recession. (Gamber, 2023) Output is determined by the Euler equation, and since the real interest rate is fixed, it remains unchanged. The remaining producers make up the slack in output from the missing entrants. However, because of decreasing returns to scale in the production function, these producers must use more labor to produce the same level of output, leading employment to

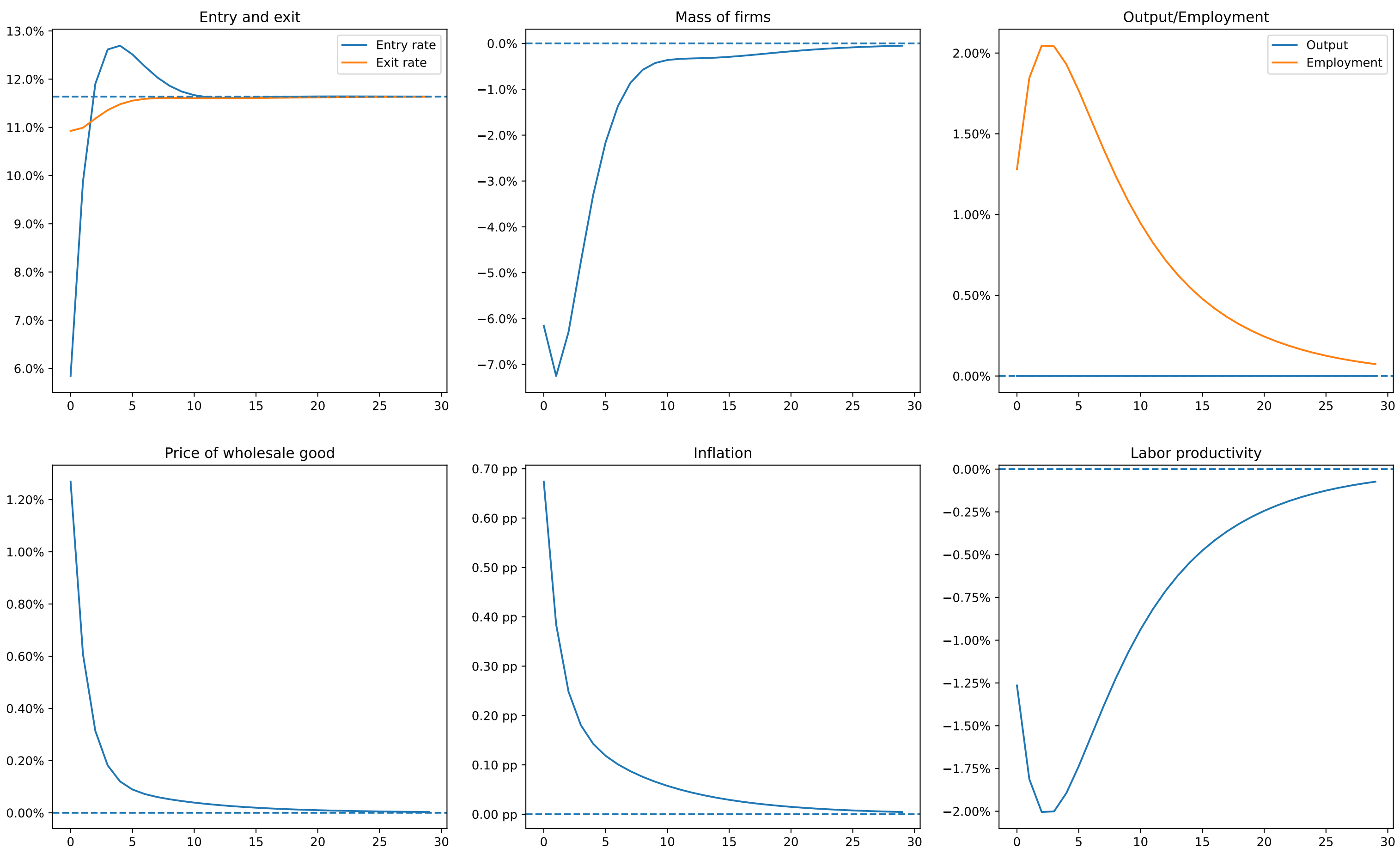
[4]As I show in appendix ??, a shock to exit produces similar results, as exiting producers are similar in size to entrants.

[5]That said, it produces counterfactual output and employment dynamics; since output is determined by the Euler equation and the interest rate is fixed, output is unchanged. The reduction in the number of firms requires remaining producers to grow, but because output has diminishing returns, overall employment must grow to produce the same quantity of output.

rise.

As the bottom right left shows, the real price of the wholesale good then rises by a bit over one percent in order to induce the remaining producers to meet demand for their output. The increase in the real price reflects their increased marginal costs, as well as the cost to adjusting labor that these producers must pay. The increase in the price of the wholesale good then passes on to inflation through the price Phillips curve, resulting in a persistent increase in the inflation rate of nearly 0.7 percentage point on impact. Labor productivity, defined as the ratio of output to employment declines by 2 percent, reflecting the higher marginal costs of the incumbent producers.

Figure 8: Shock to the cost of entry with a fixed real interest rate



The upward pressure on inflation coming from the reduction in the number of producers helps explain the relatively stable inflation rate during the Great Recession, a period with considerably elevated economic slack. A large literature on this issue offered different explanations for this phenomenon of "missing deflation." (See, e.g., Gilchrist et al. (2017) and references therein) In this paper, I offer an alternative theory: the decline in the number of operating businesses during this period acted like a supply shock, reducing productive capacity and increasing the rate of inflation.

5.2 Monetary shocks with endogenous firm dynamics

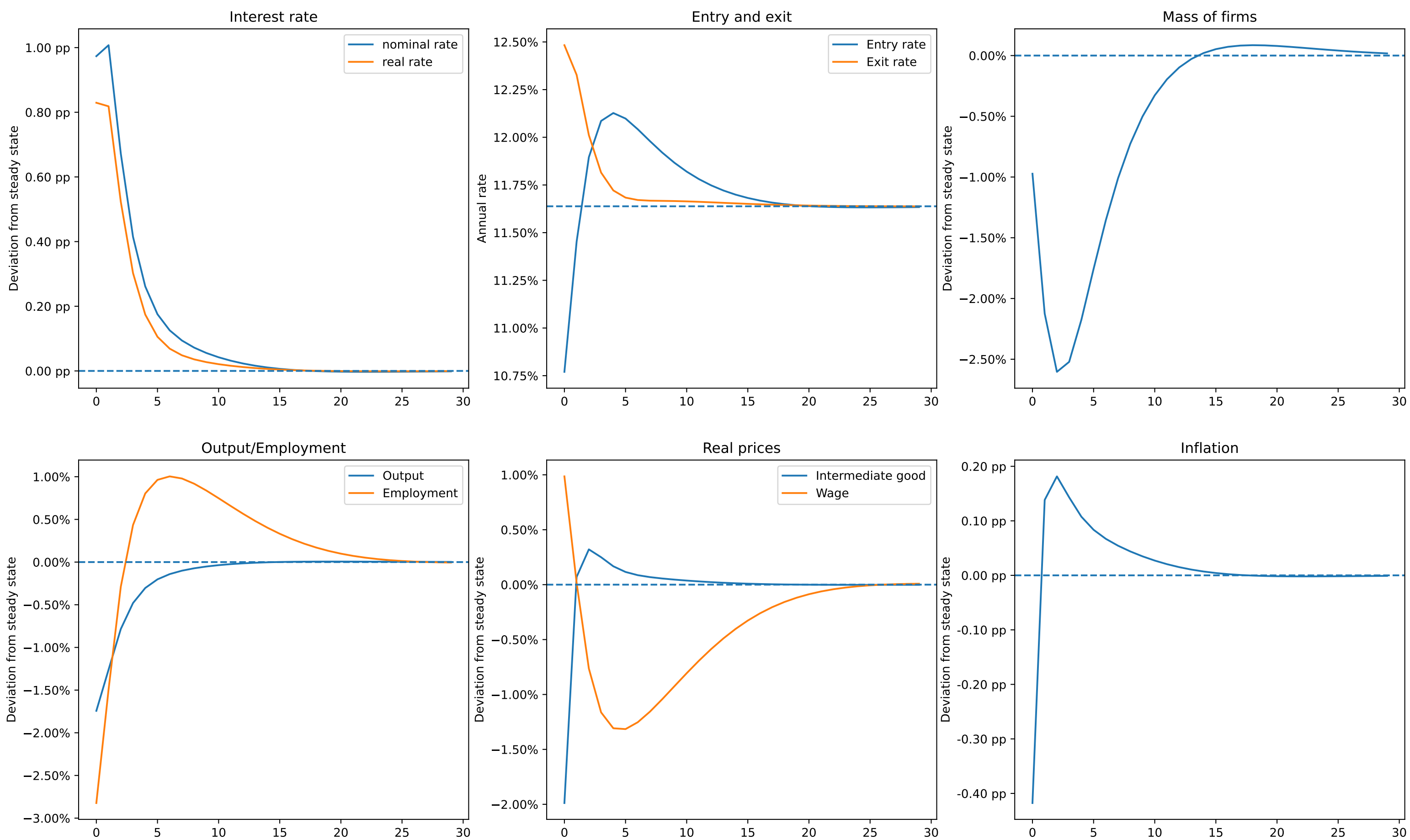
I next explore the real effects of monetary policy when business formation and destruction endogenously respond to the interest rate. To that end, figure 9 shows the impact of a persistent contractionary shock to monetary policy in the economy. I choose the size of the shock to generate a 100bps increase in the federal funds rate on impact, and it decays at a rate of 50 percent per year. The increase in the nominal interest rate leads the real interest rate to rise persistently, as shown in the top left panel.

As shown in the top middle panel, the higher interest rate leads the mass of entering producers to decline and the mass of exiting producers to rise—in line with time series evidence. These effects occur both through the direct effects of the interest rate on the value of entry and the value of continuing, as well as through the effects of the increase in the interest rate on the cost of entry and the fixed cost to produce. These effects were calibrated to match the evidence presented in section 4. The mass of producers, shown in the top right panel, has a hump-shaped response, peaking at around 1.4 percent below its steady state level.

Following the monetary tightening, output and employment decline, as shown in the bottom left panel. The impact responses are standard in a New Keynesian model. However, employment overshoots, as incumbent producers need to meet demand at a higher marginal cost. The next panel shows the responses of the real price of the wholesale good and the wage. The price of the wholesale good declines on impact, as weaker demand lowers the wholesale producer's desired level of production. However, as demand recovers but the mass of producers remains persistently depressed, the price for the intermediate good rises somewhat above its steady state level. These dynamics feed into inflation, shown in the bottom right panel. While the shock lowers inflation by roughly $\frac{1}{2}$ percentage point on impact, it quickly overshoots as the increase in the intermediate good price passes through into final goods prices. Inflation peaks at around 0.2 percentage point above its steady state level and then gradually returns back to steady state.

Baqaee, Farhi and Sangani (2024) show that labor productivity declines in response to a contractionary monetary policy shock, identified using the Romer and Romer (2004) methodology. This paper provides an alternative explanation for this phenomenon: the reduction in the number of producers leads labor to reallocate toward incumbents, who must increase their scale to do so. Because they face decreasing returns, incumbents' marginal products fall, leading labor productivity (Y/L) to decline.

Figure 9: A monetary shock



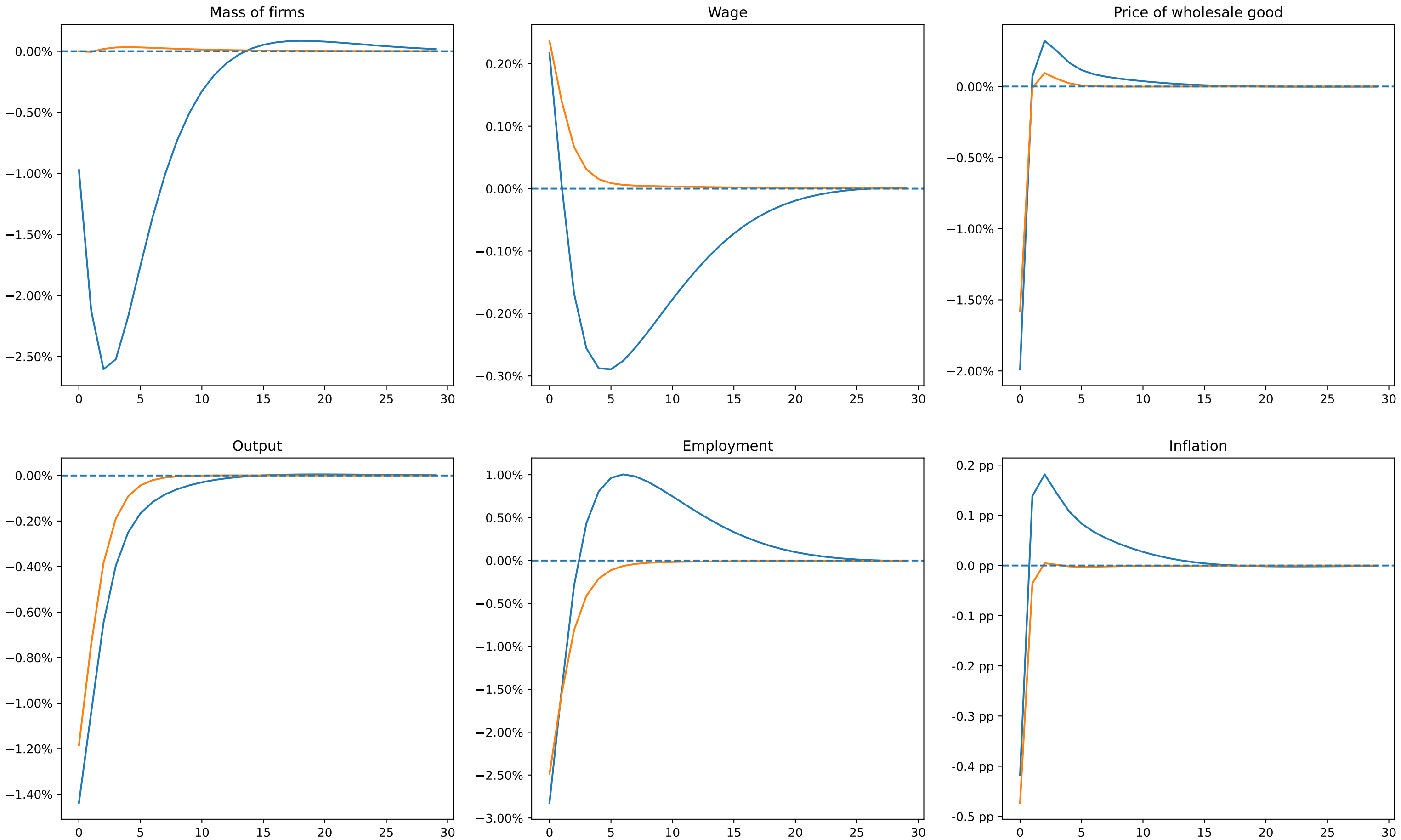
5.3 The role of firm dynamics

To understand the role of entry in the transmission of policy, I compare the impulse response of the baseline economy to one in which I keep the mass of entrants and exiters at its steady state level.[6] Figure 10 shows the effect of the shock in these two models.

Introducing endogenous fluctuations in business formation meaningfully affects the responses of employment, inflation, and the real wage. First, the presence of firm dynamics in the model amplifies the output and employment responses on impact, by a bit under 20 percent. Moreover, despite having a contractionary effect on impact, the shock to the Taylor Rule leads employment and inflation to overshoot quite persistently in the periods following the shock. In this model, monetary policy thus has different effects at different horizons; after having an initial contractionary effect for employment and inflation, it has a more expansionary effect thereafter. This pattern suggests a tradeoff for policymakers with a dual mandate; a change in the policy rate to move inflation or employment closer to a target in the short-run will move it further away in the medium-run.

[6] In practice, I set the elasticity of the entry cost to the mass of entrants to a very high number, and I choose an elasticity of the exit cost to the interest rate that dampens most of the fluctuation in exit.

Figure 10: The role of firm dynamics



6 Conclusion

In this paper, I study how firm dynamics affect business cycles and the transmission of monetary policy. To do this, I develop a New Keynesian model with endogenous business formation and destruction and use the model as a laboratory to study the transmission of shocks. I find two key results: (1) a decline in business formation (or an increase in destruction) leads inflation to rise and average labor productivity to decline persistently; (2) endogenous fluctuations business formation changes the transmission of monetary policy shocks, leading inflation to overshoot in the medium-run, as monetary policy affects the productive capacity of the economy.

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