# Entry Costs and Aggregate Dynamics*

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**Abstract**

We use a structural model to study the interaction between barriers-to-entry, investment, and monetary policy. We first show that entry cost shocks have distinct macroeconomic implications: they raise markups but reduce aggregate demand and investment in such a way that inflation barely changes. Entry costs can thus rationalize the coexistence of increasing markups and low inflation. We then estimate the model on U.S. data. We find that entry costs have risen in the U.S. over the past 20 years and have depressed capital by about 5% and consumption by about 8%. Absent entry cost shocks, the real interest rate would have been about 1 percentage point higher over 2009 to 2012.

*Keywords*: Corporate Investment, Competition, Tobin's $Q$, Zero Lower Bound.

*JEL classifications*: E2, E4, E5, L4.

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# 1 Introduction

Four stylized facts characterize the U.S. economy in recent decades: (i) a decline in the equilibrium real interest rate and a frequently binding zero lower bound; (ii) a steady rise in corporate profits and industry concentration; (iii) a fall in business dynamism – including firm entry rates and the share of young firms in economic activity; and (iv) low business investment relative to measures of profitability, funding costs, and market values.[1]

The goal of our paper is to study whether changes in barriers-to-entry can account for these stylized facts. While these stylized facts are well established (Decker, Haltiwanger, Jarmin and Miranda, 2014; Furman, 2015; Grullon, Larkin and Michaely, 2019; Gutiérrez and Philippon, 2017), their interpretation remains controversial. There is little agreement about the causes and consequences of these evolutions. For instance, Furman (2015) and CEA (2016) argue that the rise in concentration suggests "economic rents and barriers to competition", while Autor et al. (2017) argue almost exactly the opposite: that concentration reflects "a winner takes most feature" explained by the fact that "consumers have become more sensitive to price and quality due to greater product market competition." The evolution of profits and investment could also be explained by intangible capital deepening, as discussed in Crouzet and Eberly (2018).[2]

Several reasons explain why the literature has remained inconclusive. The first challenge is that entry, exit, concentration, investment, and markups are all jointly endogenous. The second challenge is that the macroeconomic implications of declining competition are difficult to analyze outside a fully specified model.

Our paper makes two contributions. The first contribution is to propose a model where all changes in competition come from changes in entry costs. Most macroeconomic models, by

[1]See Section 2 for additional details on these facts.

[2]Finally trade and globalization can explain some of the same facts (Feenstra and Weinstein, 2017; Impullitti et al., 2017). Foreign competition can lead to an increase in domestic concentration and a decoupling of firm value from the localization of investment. We control for exports and imports in our analyses. Foreign competition is significant for about 3/4 of the manufacturing sector, or about 10% of the private economy. One could entertain other hypotheses – such as weak demand or credit constraints – but previous research has shown that they do not fit the facts. See Covarrubias et al. (2019) for detailed discussions and references.

contrast, simply assume exogenous changes in markups and study the implications without explicitly linking them to barriers-to-entry. We show that this can lead to mis-specifications of macroeconomic dynamics. For instance, in a standard new Keynesian model, an exogenous increase in markups leads to a temporary increase in inflation. In our model, instead, a rise in entry costs increases markups without increasing inflation. The reason is that the lack of entry drives down investment and aggregate demand.

Our second contribution is to perform a Bayesian estimation of the model, thus bridging the gap between the traditional DSGE literature (Smets and Wouters, 2007) and a growing IO literature (De Loecker et al., 2020). The key innovation is that our estimation uses data on entry, investment, and stock market valuations to recover shocks to the entry equation. We use the estimated model to study the macroeconomic consequences of entry costs.

Our findings suggest that entry cost shocks account for much of the increase in aggregate concentration and that they have large effects on aggregate investment, the natural interest rate, and the stance of monetary policy. In our counterfactual exercise, we find that absent entry cost shocks, the aggregate Herfindahl index would have been about 15% lower by 2015, the capital stock would have been about 5% higher, and consumption would have been about 8% higher. Absent these entry cost shocks, the real rate would be higher by between 0.5 to 1.5 percentage points over the 2009 to 2012 period, roughly the same amount as the contribution of forward guidance by the Federal Reserve.

**Literature.** We estimate a general equilibrium model with time varying-entry and competition, and an occasionally binding lower bound on interest rates. Our work therefore relates to three distinct lines of research. The first is the literature on entry dynamics. Bernard et al. (2010) estimate that product creation by both existing firms and new firms accounts for 47 percent of output growth in a 5-year period. Decker et al. (2015) argue that, whereas in the 1980's and 1990's declining dynamism was observed in selected sectors (notably retail), the decline was observed across all sectors in the 2000's, including the traditionally high-growth information technology sector (see also Kozeniauskas, 2018; Davis and Haltiwanger, 2019). Bilbiie et al. (2008) study how entry affects the propagation of business cycles in a New Keynesian model and Bilbiie et al. (2012) study a real business cycle model. There are two main differences between our work and theirs. The theoretical difference is that we take into account the zero lower bound on interest rates. This adds complexity to the estimation but it is unavoidable in our sample. The empirical difference is that we estimate the model using a Kalman filter, and we use information from the stock market as well as the time series of import-adjusted industry concentration. Without this information it is impossible to identify entry shocks.

Our paper is also related to a long literature in IO that studies the evolution of industries when entry costs are (at least partly) endogenous (Stigler, 1971; Sutton, 1991, 1997). Cacciatore and Fiori (2016) estimate that reducing entry costs in Europe to the level observed in the U.S. in the late 1990s would have increased investment by 6% (see also Cacciatore et al., 2017; Lincoln and McCallum, 2018; Maggi and Felix, 2019; Edmond et al., 2019) A recent literature has focused on the macroeconomic consequences of time-varying competition in the US. An important issue in the literature concerns the measurement of markups and excess profits. De Loecker et al. (2020) estimate markups using the ratio of sales to costs-of-goods-sold and find a large increase in markups. Barkai (2017), on the other hand, estimates the required return on capital directly and finds a moderate increase in excess profits. Both estimates are controversial (Basu, 2019; Syverson, 2019; Covarrubias et al., 2019). For tractability our model assume that active firms are homogenous and our quantitative analysis focuses on aggregate variables. One should keep in mind, however, that these aggregate values hide a lot of heterogeneity, as emphasized in the literature.

Following Eggertsson and Woodford (2003), a large literature has studied the consequences of a binding ZLB on the nominal rate of interest, and the liquidity trap (Eggertsson et al., 2019; Swanson and Williams, 2014) propose a model of secular stagnation, including a study of the role of demographic changes. Swanson and Williams (2014) study the impact on long rates. Most studies of the liquidity trap are based on simple New-Keynesian models that abstract from capital accumulation.[3] Capital accumulation complicates matters, however, as consumption and investment can move in opposite directions.

Eggertsson et al. (2018) and Corhay et al. (2018) are perhaps the closest papers to our work. Eggertsson et al. (2018) take entry as exogenous and model a time-varying elasticity of substitution between intermediate goods to study the ability of time-varying market power to explain a number of broad macroeconomic trends. Corhay et al. (2018) develop an innovation-based endogenous growth model with aggregate risk premia and endogenous markups; and use it to decompose the rise in $Q$ into revised growth expectations, rising market power, and changes in risk premia. Corhay et al. (2018) conclude that declines in competition explain a large portion of the increase in $Q$. Albeit with a different structure, our model also features endogenous entry decisions sensitive to future demand expectations.

## 2 Motivating Stylized Facts

We begin with four stylized facts that guide our analyses.

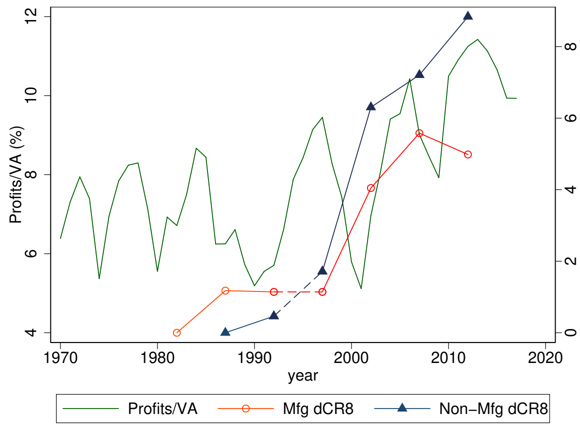
**Fact 1: Interest rates have fallen.** We first note that, as is well-known, real interest rates have fallen, as have estimates of the natural interest rate. Nominal interest rates have also fallen, with the Federal Funds rate at the zero lower bound between 2009 and 2015, and again from 2020. We plot these series in the Online Appendix.

**Fact 2: Profits and concentration have increased.** Figure 1(a) shows the ratio of Corporate Profits to Value Added for the U.S. Non-Financial Corporate sector, along with the cumulative weighted average change in the 8-firm concentration ratio in manufacturing and non-manufacturing industries. As shown, both series increased after 2000. These patterns are pervasive across industries as shown by Grullon et al. (2019).

[3] See Fernández-Villaverde et al. 2015 for the exact properties of the New Keynesian model around the ZLB.

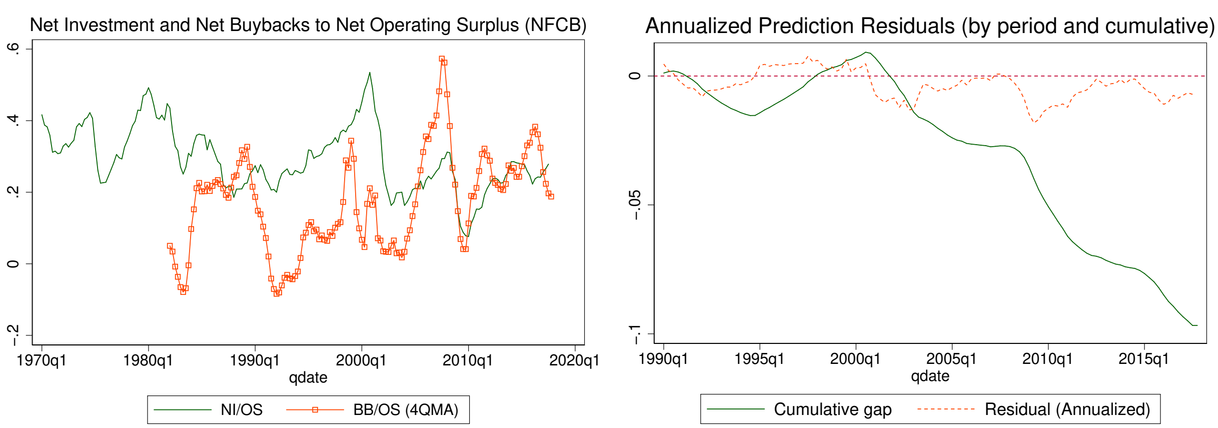
Figure 1: Motivating Stylized Facts

(a) Concentration and Profits

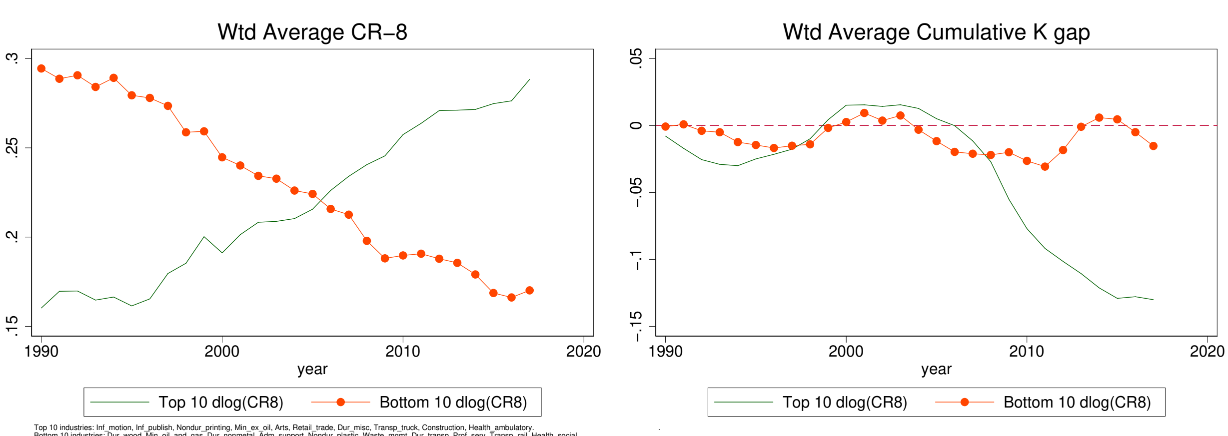



(b) Firm Entry and Exit Rates


(c) Net Investment, Profits and Q-Residuals




(d) Cumulative Capital Gap for Concentrating and Non-Concentrating Industries




Notes: Figure notes are provided in the Appendix.

**Fact 3: Entry rates have fallen.** Figure 1(b) plots aggregate entry and exit rates from the Census BDS. Entry rates began to fall in the 1980s and accelerated after 2000. Exit rates, by contrast, have remained stable. This is true at the aggregate and industry-level, and when controlling for profits or Tobin's $Q$, as shown in Gutiérrez and Philippon (2019).

**Fact 4A: Investment is low relative to profits and Q.** The left chart in Figure 1(c) shows the ratio of aggregate net investment and net repurchases to net operating surplus for the non financial corporate sector, from 1960 to 2015. As shown, investment as a share of operating surplus has fallen, while buybacks have risen. The right chart shows the residuals (by year and cumulative) of a regression of net investment on (lagged) $Q$ from 1990 to 2001, illustrating that investment has been low relative to $Q$ since the early 2000's. By 2015, the cumulative under-investment is large at around 10% of capital. The decline appears across all asset types, notably including intangible assets (Covarrubias et al., 2019).

**Fact 4B: The lack of investment comes from concentrating industries.** Finally, Figure 1(d) shows that the capital gap is coming from concentrating industries. The solid (dotted) line plots the implied capital gap relative to $Q$ for the top (bottom) 10 concentrating industries. For each group, the capital gap is calculated based on the cumulative residuals of separate industry-level regressions of net industry investment from the BEA on our measure of (lagged) industry $Q$ from Compustat. This result highlights why it is critical to consider investment alongside concentration.

# 3 Model

To explain the drivers behind these facts, we use a model with capital accumulation, nominal rigidities, and time-varying competition with firm entry. For accounting simplicity, we separate firms into capital producers who lend their capital stock, and good producers who hire capital and labor services to produce goods and services.[4] Many of the features of our model are standard to the New Keynesian literature (see for example Smets and Wouters, 2007; Gali, 2008), and we focus in this section on the new and non-standard additions to the basic framework, namely: (i) firm entry, and (ii) monetary policy at the ZLB. The Appendix describes the remaining features of our model.

## 3.1 Goods Producers

The economy is populated by firms indexed by $i$ who face pricing and production decisions. The firms' output is aggregated into an industry output

$$Y_t = \left( \int_0^{N_t} y_{i,t}^{\frac{\epsilon-1}{\epsilon}} \mathrm{d}i \right)^{\frac{\epsilon}{\epsilon-1}}. \tag{1}$$

where $N_t$ is the number of active firms active at time period $t$ and $\epsilon$ is the elasticity of substitution across firms. The price index is defined as $P_t = \left( \int_0^{N_t} p_{i,t}^{1-\epsilon} \mathrm{d}i \right)^{\frac{1}{1-\epsilon}}$. Firm $i$ has access to a Cobb-Douglas production function with stationary TFP shocks $A_t$,

$$y_{i,t} = A_t k_{i,t}^{\alpha} \ell_{i,t}^{1-\alpha}, \tag{2}$$

and takes economy-wide wages $W_t$ and the real rental rate $R_t^k$ as given when they maximize profits

$$\mathrm{Div}_{i,t} = \max_{\{p_{i,t}, \ell_{i,t}, k_{i,t}\}} \frac{p_{i,t}}{P_t} y_{i,t} - \left( \frac{W_t}{P_t} \ell_{i,t} + R_t^k k_{i,t} + \phi \right). \tag{3}$$

In the full model presented in the Appendix we also introduce intermediate inputs because the distinction between value added and gross output matters for the calibration of markups. For expositional reasons, here we ignore intermediate inputs. The marginal cost $\chi_t$ is

$$\chi_t = \frac{1}{A_t} \left( \frac{R_t^k}{\alpha} \right)^{\alpha} \left( \frac{W_t/P_t}{1-\alpha} \right)^{1-\alpha}. \tag{4}$$

[4] This assumption simply allows us to maintain the standard $Q$-equation and the standard Phillips curve.

Factor choices in the firm's problem imply the choice of capital and labor are simply $k_{i,t} = \alpha \frac{\chi_t}{R_t^k} y_{i,t}$ and $\ell_{i,t} = (1-\alpha)\frac{\chi_t}{W_t/P_t} y_{i,t}$. All firms choose the same capital to labor ratio.

## 3.2 Markups and Prices

In the full model used for estimation we assume that firms face nominal rigidities in order to obtain well-behaved industry Phillips curves.[5] These rigidities have second order effects on values, productivities, and on the dispersion of firm level output. We thus simplify the exposition by presenting here the flexible price equations. All firms set the same price and thus have the same output:

$$Y_t = \left( \int_0^{N_t} y_{i,t}^{\frac{\epsilon-1}{\epsilon}} \mathrm{d}i \right)^{\frac{\epsilon}{\epsilon-1}} = y_t \left(N_t\right)^{\frac{\epsilon}{\epsilon-1}} . \tag{5}$$

where, with some abuse of notation, we denote by $y_t$ the average firm output. The difference between the average of individual outputs $y$ and aggregate output $Y$ highlights the positive impact of product variety on productivity: ${}^{Y_t}/_{N_t} = y_t \left(N_t\right)^{\frac{1}{\epsilon-1}}$, that is, average output $Y/N$ is increasing in $N$ holding $y$ fixed.

With flexible prices, firms set each period a markup over marginal cost: $\frac{p_{i,t}}{P_t} = \mu_t \chi_t$. We consider a setup where the markup decreases with the number of firms. Many models would deliver this prediction. One could consider Cournot competition among large firms. One could introduce limit pricing with an entry threat increasing in $N_t$. One could also modify the CES preferences in (5) along the lines of Kimball (1995). We have explored these various modeling choices and found that what matters is the resulting link between $N$ and $\mu$ – which

[5]Formally, we assume that firms set prices à la Calvo so that the reset price at time $t$, $p_{i,t}^*$, solves

$$\mathbb{E}_t \left[ \sum_{k=0}^{\infty} \vartheta_p^k \Lambda_{t+k} y_{i,t+k} \left( 1 - \epsilon_j + \epsilon_j \frac{P_{t+k}}{p_{i,t}^*} \chi_{t+k} \right) \right] = 0.$$

Indexation keeps the dispersion of prices small. In addition, we estimate relatively small nominal rigidities, so the impact of these rigidities on productivity (output) and value (Tobin's $Q$) are negligible.

we estimate – not the specific micro-foundation. We specify the markup directly as

$$\log \mu_t = \log \frac{\epsilon}{\epsilon - 1} - \phi_\mu \log N_t + \zeta_t^\mu. \qquad (6)$$

The baseline New Keynesian model assumes $\phi_\mu = 0$. In our simulations with US data, we use $\phi_\mu \sim 0.3$. The shock $\zeta_t^\mu$ is useful for two reasons. The first reason is the estimation of the model where we use a time series for inflation, as in the New Keynesian literature (for example Smets and Wouters, 2007). The second reason is that this shock allows us to study the theoretical effects of pure markup shocks and compare them to entry cost shocks.

### 3.3 Entry

Firm entry plays an important role in our analysis. There are several notions of entry in the literature. In models of the firm "life cycle" following Jovanovic (1982) and Hopenhayn (1992), entry is best thought of as the early stage of production. This is particularly clear in models of learning-by-doing. In models of venture capital financing, there are various stages of entry, from the initial idea to the exit of the first limited partners. In models with large firms, entry should correspond to the stage where the size of the firm becomes significant.

Ours is a model of large firms so we think of entry as the acquisition of a large enough scale. The economy consists of an exogenous competitive fringe of small firms and a index $N$ of large firms. Given the constant returns in production and capital accumulation, the competitive fringe only affects the equilibrium via the markup equation (6), so we can ignore it and focus on the large firms. One can think of this assumption as a simplified version of Cavenaile et al. (2020).

Potential entrants pay an entry cost to become active producers in the subsequent period.[6]

[6] Our focus in on the time variation of entry costs. See Bilbiie, Ghironi and Melitz (2006) for a discussion of corrective taxes.

Let $N_t$ be the number of firms. The number of large firms active at time $t+1$ is

$$N_{t+1} = (1-\delta_n)N_t + n_t. \tag{7}$$

Each active firms disappears with probability $\delta_n$, while $n_t$ is the number of entrants that become active in period $t+1$. An exogenous exit rate is consistent with the data, as reported by Lee and Mukoyama (2018). Entry requires a fixed input $\kappa_t$ produced competitively with a convex cost function, so that the input price $p_t^e$ is

$$p_t^e = (\kappa_t n_t)^{\phi_n}, \tag{8}$$

with $\phi_n \geq 1$. The elasticity of the number of entrants $n_t$ to rents depends on the parameter $\phi_n$. We discuss the parameterization of the model in Section 5.

Our entry costs capture the cost of becoming a large firm. In models of Schumpeterian competition such as Akcigit and Ates (2019), this cost would correspond to the sum of entry costs plus the total investment required to catch up with the leader. These costs includes technological investment as well as regulatory costs. The key simplifying assumption embedded in equation (7) is that all large firms have the same productivity. This assumption is consistent with the findings in Gutiérrez and Philippon (2020) that, among large firms, relative productivity has remained stable over the past decades. This assumption simplifies the aggregation of firms and allows us to explore complicated macroeconomic dynamics. The main downside is that we cannot address the heterogeneity described in De Loecker et al. (2020).[7] We focus on aggregate variables and one should keep in mind that they hide a lot of heterogeneity.

[7] An ideal model would allow for both firms life cycle effects and non-linear macro dynamics at the ZLB, but it would become computationally intractable and we would not be able to perform the Bayesian estimation. Using this simplifying assumption we obtain a model that can be solved in a few hours and we are able to compare our results to those in standard DSGE models (Smets and Wouters, 2007).

Free entry then requires that

$$p_t^e \kappa_t \geq \mathbb{E}_t \Lambda_{t+1} V_{t+1}, \tag{9}$$

where $\Lambda_t$ is the household's pricing kernel and $V_t$ is the value of the goods-producing firm given by

$$V_t = \text{Div}_t + (1 - \delta_n) \mathbb{E}_t \Lambda_{t+1} V_{t+1}, \tag{10}$$

where $\text{Div}_t$ are real dividends, defined above. Equation (9) must hold with equality as long as $n_t > 0$, which is the case in our simulations. Our assumption of convex entry costs in (8) slows entry during booms, which helps match the volatility of entry rates and their relationship to asset prices. This convexity can have multiple interpretations, from diminishing quality in managerial ability (Bergin, Feng and Lin, 2017) to congestion effects in firm creation (Jaef and Lopez, 2014), perhaps due to a limited supply of venture capital needed to finance and monitor entrants (Loualiche, 2016). The entry cost $\kappa_t$ is subject to autoregressive shocks: $\kappa_t = \kappa + \zeta_t^\kappa$ with

$$\zeta_t^\kappa = \rho_\kappa \zeta_{t-1}^\kappa + \sigma_\kappa \epsilon_t^\kappa. \tag{11}$$

In this model, entry costs regulate the link between entry of new firms and the market value of incumbents, they therefore capture not only technological costs, but also administrative costs and regulatory barriers, and deterrence by incumbents.[8]

[8] In a companion paper, Jones, Gutiérrez and Philippon (2020), we show that the estimated entry cost series at the industry level relative to the aggregate correlates with relative changes in regulation and in M&A activities.

## 3.4 Investment

We assume that the capital good is produced by competitive, constant-return-to-scale firms. Aggregate capital accumulates as

$$K_{t+1} = (1-\delta)\,K_t + I_t. \tag{12}$$

The solution of the investment problem is the standard $Q$-investment equation,

$$x_t = \frac{1}{\phi_k}\left(Q_t^k - 1\right), \tag{13}$$

where $x_t$ is the net investment rate and Tobin's $Q$ satisfies the recursive equation

$$Q_t^k = \mathbb{E}_t\left[\Lambda_{t+1}\left(R_{t+1}^k + Q_{t+1}^k - \delta + \frac{1}{2\phi_k}\left(Q_{t+1}^k - 1\right)^2\right)\right].$$

In the logic of the $Q$-theory of investment, $Q_t^k$ is the discounted value of operating returns, $R_{t+1}^k$, plus future $Q_t^k$ net of depreciation, plus the option value of investing more when $Q_t^k$ is high, and less when $Q_t^k$ is low. This setup is standard and the details are relegated to the Appendix.

When we map our model to the data we take into account that our empirical measure of aggregate firm value reflects not only the usual capital adjustment costs but also monopolistic rents. Aggregate Tobin's $Q$ is therefore

$$Q_t \equiv Q_t^k + \frac{N_{t+1}(1-\delta_n)\mathbb{E}_t\left[\Lambda_{t+1}V_{t+1}\right]}{P_t K_{t+1}}. \tag{14}$$

## 3.5 Households

We introduce a standard household sector and wage setting mechanism. Households maximize lifetime utility

$$\mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\gamma}}{1-\gamma} - \frac{\ell_t^{1+\varphi}}{1+\varphi} \right) \right],$$

subject to the budget constraint

$$S_t + P_t C_t \leq \tilde{R}_t S_{t-1} + W_t \ell_t,$$

where $W_t$ is the nominal wage and $\tilde{R}_t$ is the (random) nominal gross return on savings from time $t-1$ to time $t$. The household's real pricing kernel between periods $t$ and $t+j$ is

$$\Lambda_{t+j} = \beta^j \left( \frac{C_t}{C_{t+j}} \right)^{\gamma}.$$

By definition of the pricing kernel, nominal asset returns must satisfy

$$\mathbb{E}_t \left[ \Lambda_{t+1} \frac{P_t}{P_{t+1}} \tilde{R}_{t+1} \right] = 1.$$

Wage setting takes place as in the standard New Keynesian model with Calvo-style wage rigidities (see Gali, 2008).

## 3.6 Shocks and Monetary Policy

To estimate the model with a Kalman filter we add shocks to match the number of observables. The entry cost shock $\zeta_t^{\kappa}$ was discussed earlier. A discount rate shock $\zeta_t^{b}$ to the pricing kernel helps capture the sharp drop in risk free rates during the Great Recession, as is standard in the New Keynesian literature. A risk-premium shock to the valuation of corporate assets $\zeta_t^{q}$ helps us match time-varying expected returns and the volatility of the stock market relative to the bond market. We include a TFP shock $\zeta_t^{z}$ and a markup shock that, in reduced form, augments the inflation Phillips curve $\zeta_t^e$. All these processes have an autoregressive structure. For instance, the risk premium shock is:

$$\zeta_t^q = \rho_q \zeta_{t-1}^q + \sigma_q \epsilon_t^q.$$

To close the model, we specify a policy rule for the central bank, taking into account the ZLB on nominal interest rates. We assume that monetary policy follows a standard Taylor rule for the nominal interest rate

$$\tilde{r}_t^* = -\log(\beta) + \phi_r \tilde{r}_{t-1}^* + (1-\phi_r)\left(\phi_p \pi_t^p + \phi_y \left(\ln Y_t - \ln Y_t^F\right)\right) + \phi_g \ln\left(\frac{Y_t / Y_{t-1}}{Y_t^F / Y_{t-1}^F}\right) + \sigma_r \epsilon_t^r,$$

where $\pi_t^p$ is price-level inflation, $Y_t^F$ is the flexible price level of output and $\epsilon_t^r$ is a monetary policy shock. We assume that the actual (log) short rate can be at the ZLB:

$$\tilde{r}_t = 0.$$

**ZLB Durations and Forward Guidance** To capture the conduct of monetary policy over the lower bound period, we allow for forward guidance policy in the following way. Following Jones, Kulish and Rees (2021), each lower bound episode has a duration which is communicated by the central bank and expected by agents in the economy. We denote this duration by $\mathbf{d}_t$ and it is forecast to shrink by one period each period, or $\mathbb{E}_t \mathbf{d}_{t+1} = \mathbf{d}_t - 1$. The duration $\mathbf{d}_t$ is decomposed into two components. The first component, denoted by $\mathbf{d}_t^{\text{lb}}$, is the duration which is implied by the structural shocks and the condition

$$\tilde{r}_t = \max\left(0; \tilde{r}_t^*\right). \tag{15}$$

This is the length of time that the ZLB binds given the state of the economy in period $t$, the structural shocks that occur at $t$, and the constraint (15). It is the duration that would arise if the central bank were to simply follow the prescription of the Taylor Rule when forming expectations at $t$ about when the policy rate will lift off from the ZLB. For example, when at the ZLB, a contractionary shock that hits at period $t$ and causes the path of $\tilde{r}_t^*$ to fall will cause the constraint (15) to bind for longer in expectation and so $\mathbf{d}_t^{\text{lb}}$ to increase.

The second element of the duration $\mathbf{d}_t$ is the forward guidance component. This component is implicitly defined as $\mathbf{d}_t^{\text{fg}} = \mathbf{d}_t - \mathbf{d}_t^{\text{lb}}$, or the difference between the duration that is expected by agents in the economy at $t$ and $\mathbf{d}_t^{\text{lb}}$. The forward guidance duration is therefore an extension of the expected ZLB duration beyond that implied by fundamentals, the shocks, and (15), in line with the optimal policy prescription of Eggertsson and Woodford (2003) and Werning (2015). We discuss more in the estimation section how we discipline $\mathbf{d}_t$.

# 4 Why Entry Shocks Matter

Our model focuses on entry cost shocks. In particular we ask if the commonly used short-cut of simply moving the markup is without loss of generality. We find that the answer is no in several cases.

## 4.1 Theoretical Discussion

To understand the main point, consider a "three equations" New Keynesian version of our model. So let us fix the capital stock for now at $K = \bar{K}$ and impose $c = y$. The inflation equation becomes

$$\pi_t = \lambda \left( \mathtt{mc}_t - \phi_\mu \hat{n}_t + \zeta_t^\mu \right) + \beta \mathbb{E}_t \left[ \pi_{t+1} \right], \tag{16}$$

where $\hat{n}_t \equiv \log \left( N_t / \bar{N} \right)$, and $\lambda$ depends on the Calvo parameter and on the curvature of the marginal cost. The aggregate output equation is

$$\hat{y}_t = (1-\alpha)\,\ell_t + a_t + \bar{\mu}\hat{n}_t.$$

The other equations (labor supply, marginal cost, Euler equation) are standard and we omit the shocks that are not important for our current discussion:

$$\begin{aligned} \omega_t &= \varphi \ell_t + \gamma \hat{y}_t \\ \texttt{mc}_t &= \omega_t - a_t + \alpha \ell_t \\ \hat{y}_t &= \mathbb{E}_t \left[ \hat{y}_{t+1} \right] - \frac{1}{\gamma} \left( r_t - \mathbb{E}_t \left[ \pi_{t+1} \right] \right). \end{aligned}$$

From the production function we have $\ell_t = \frac{\hat{y}_t - a_t - \bar{\mu} \hat{n}_t}{1-\alpha}$, so the marginal cost is

$$\texttt{mc}_t = \left( \gamma + \frac{\alpha + \varphi}{1 - \alpha} \right) \hat{y}_t - \frac{1 + \varphi}{1 - \alpha} a_t - \frac{\varphi + \alpha}{1 - \alpha} \bar{\mu} \hat{n}_t.$$

Conditional on $n$ we have a simple NK model with a Phillips curve and an Euler equation.

**Entry Shocks vs TFP Shocks** What is the impact of an entry cost shock compared to a technology shock? The number of firms is predetermined so the marginal cost does not change on impact. The number of firms will be reduced in the future, which will lower future output. From the Euler equation, this lowers current demand, which lowers marginal cost. When markups are constant ($\phi_\mu = 0$), this leads to lower inflation today.

***Remark 1****: An entry cost shock lowers current output and inflation.*

The contrast with a negative TFP shock is interesting. A negative TFP shock is inflationary because of its direct impact on marginal cost. An entry cost shock with exogenous markup resembles a delayed TFP shock. It has some flavor of a news shock.

**Entry Shocks vs Markup Shocks** A markup shock works in our model like a standard cost push shock in the NK model. It increases inflation and lowers output. The only difference is that increased profits can lead to higher entry, but this effect is relatively small in our estimated model.

***Remark 2***: *Unlike markup shocks and negative TFP shocks, entry cost shocks are deflationary.*

Let us now turn to simulations with the full model.

## 4.2 Exogenous Markups

Consider first the model with $\phi_\mu = 0$. In that model entry does not affect markups. This gives us a clean laboratory to test the predictions explained above. Figure 2 shows that, as explained above, markup shocks are inflationary while entry cost shocks are deflationary. Another interesting feature is that entry shocks lead to very persistent dynamics. Consumption and investment decline for many periods after the temporary shock. This reflects the fact that entry rates are not very elastic. A temporary entry cost shock lowers the number of firms and it takes a long time for entry to rebuild the stock of firms.

## 4.3 Endogenous Markups

Let us now consider the model where $\phi_\mu = 1/3$, as in our benchmark calibration. One can now understand the response of the economy simply by recognizing that it will be a mixture of the pure entry shock and the pure markup shock above. There is a stark contrast between the weak short run responses of all macro variables and their large long run responses (Figure 3). Investment does not fall much on impact but the capital stock is significantly lower in the long run.

The response of inflation is very small because the deflationary demand effect is canceled by the increased future markup. Our model can therefore potentially explain a relatively mild inflation response to shocks that increase firms' market power.

Figure 2: Pure Markup and Entry Shocks (model with exogenous markups, $\phi_\mu = 0$)

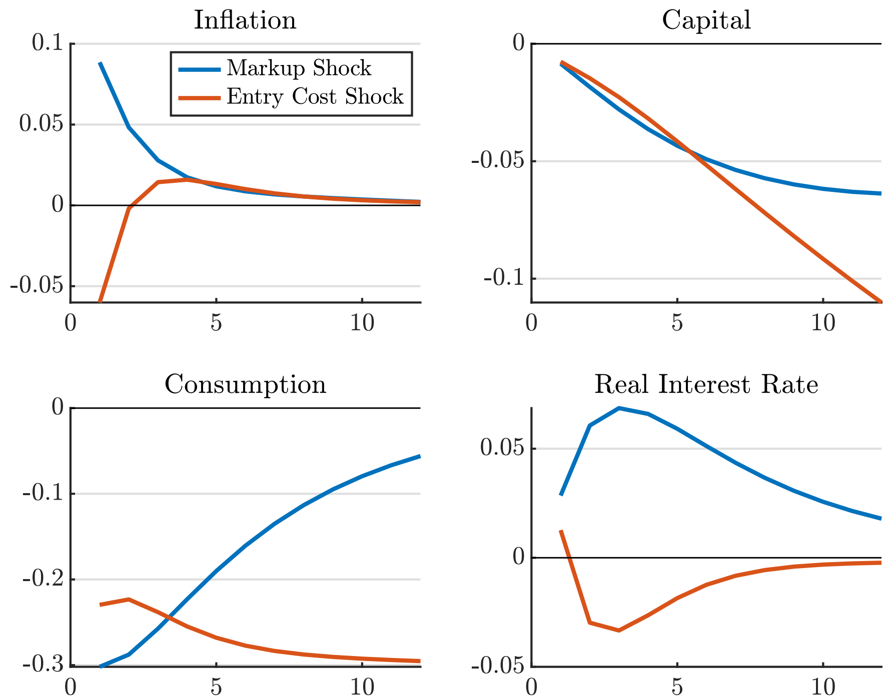
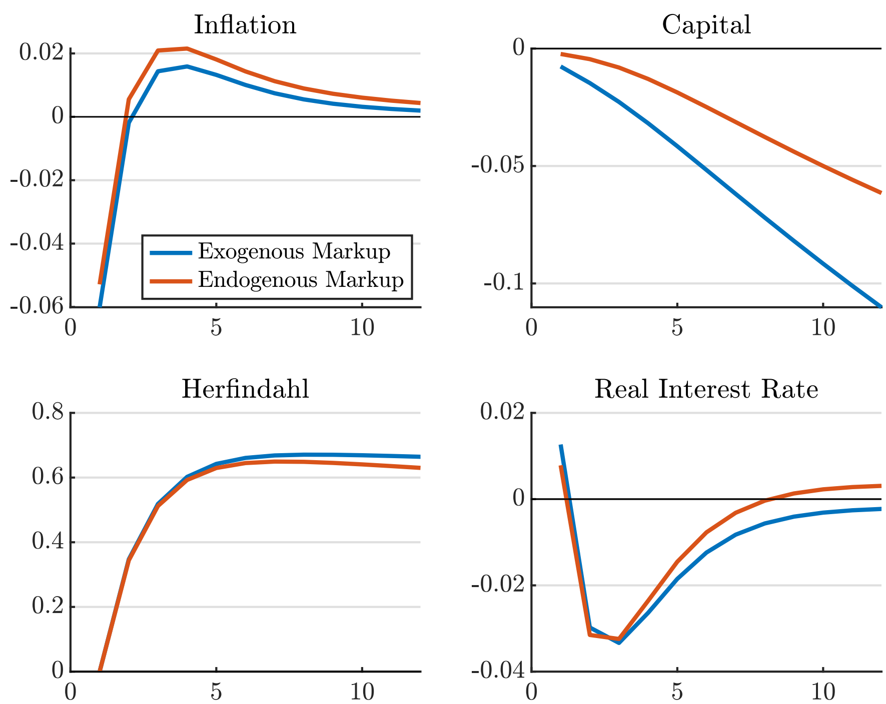



Figure 3: Entry Shocks with Endogenous Markups with $\phi_\mu = 1/3$



# 5 Estimation

We next discuss the parameterization of the model for the full quantitative analysis. We first calibrate a set of parameters to those commonly used in the literature and to moments of the data. We then estimate with Bayesian methods the persistence and size of transitory shocks, as well as the parameters of the monetary policy rule. We use the estimated model to conduct our aggregate experiments on the role of barriers to entry and its contribution to the decline in the real interest rate.

## 5.1 Parameters

Table 1 presents the assigned and calibrated parameters for our quarterly model. These estimates are based on 43 industries that cover the US Business sector.[9] We set $\delta_n$, the exogenous firm exit rate, to 0.09/4 to match the average annual exit rate of Compustat firms.[10] We calibrate the quarterly capital adjustment cost $\phi_k$ to a value of 20, in line with a regression across industries of net investment on $Q$, with a full set of time and industry fixed effects.[11]

We set the elasticity of substitution across varieties of intermediate inputs to $\epsilon = 5$, which is around the average across industries of the elasticity of substitution implied by industry-level gross operating surplus to output ratio in 1993, and which is in line with a standard calibration of the elasticity of substitution in the New Keynesian literature, implying a steady-state markup of 25%. In our estimation and experiments with $\phi_\mu > 0$, we use a value of 1/3, to be consistent with an increase in firm-level markups of around 7% since 2000,

[9] Investment and output data are available for 63 granular industry groupings from the BEA. We omit 7 industries in the Finance, Insurance and Real Estate sectors; as well as the 'Management of companies and enterprises' industry because no data is available in Compustat for it. We then group some of the remaining industries due to missing data at the most granular-level (Hospitals and Nursing and residential care facilities), or to ensure that all groupings have material investment; good Compustat coverage; and reasonably stable investment and concentration time series.

[10] We use Compustat firms to focus on the exit of large firms.

[11] We use $Q$ in this step because, in the data, there is no clear delineation of firms into goods-producers and capital-producers that would allow for separate measurements of $Q_t^k$ and $V$. Furthermore, a substantial fraction of intangible capital is produced within firms.

Table 1: Assigned Parameters

| Parameter | Value | Description | Source/Target |
|---|---|---|---|
| $\nu$ | 2 | Inverse labor supply elasticity | |
| $\beta$ | $0.97^{1/4}$ | Discount factor | |
| $\theta_p$ | 2/3 | Price setting Calvo probability | Average price contract of 3Q |
| $\theta_p$ | 3/4 | Wage setting Calvo probability | Average wage contract of 4Q |
| $\phi_k$ | 20 | Capital adjustment cost | Industry regression of $x_t$ and $Q_t$ |
| $\alpha$ | 1/3 | Capital share | |
| $\delta$ | 0.025 | Capital depreciation rate | |
| $\delta_n$ | 0.09/4 | Exogenous firm exit rate | Average annual % firm exit |
| $\epsilon$ | 5 | Industry substitution elasticity | GOS/Nominal Output in 1993 |

Notes: The parameter $\epsilon$ is chosen to match the average, across industries, of the ratio of the gross operating surplus to nominal output in 1993. The calibrated parameters which relate to the production of intermediate goods can be found in the Appendix.

while the level of concentration has increased by 25%.

One important parameter in our simulation is the elasticity of entry $\phi_n$. This parameter can only be estimated using industry-level data. We take the estimate of $\phi_n = 1.5$ from Jones, Gutiérrez and Philippon (2020) who use the cross-industry relationships between concentration, profits, and output to determine this sensitivity. This parameter will be important for quantifying the aggregate effects of entry shocks. Using aggregate-level data, we estimate the parameters of the monetary policy rule, and the persistence and variance of aggregate shocks, which we report below.

## 5.2 Data

At the aggregate level, our data is quarterly from 1989Q1 to 2015Q1. Our set of observables includes:

$$\text{Data} = \left\{ \log\left(C_t\right);\ x_t = \frac{I_t}{K_t} - \delta;\ \log\left(\ell_t\right);\ \log\left(\tilde{r}_t\right);\ \pi_t^p;\ \text{CR}_t;\ Q_t;\ \mathbf{d}_t \right\}_{t=[1989:1;2015:1]}$$

where $C_t$ is real consumption per capita, $x_t$ is the net investment rate, $\ell_t$ is hours, $\tilde{r}_t$ is the Federal Funds rate, $\pi_t$ is the inflation rate, $\text{CR}_t$ is the concentration ratio described in more detail below, $Q_t$ recall is the sum of the goods-producing and capital-producing firms' Tobin's $Q$, and $\mathbf{d}_t$ is the expected duration of the ZLB. We include hours in estimation to help identify the shocks around the Great Recession and during the ZLB period. In estimation, to ensure we have the same number of shocks as observables, we add an autoregressive measurement error to the observed $Q_t$. The persistence and standard deviation of this process are denoted by $\rho_q^*$ and $\sigma_q^*$, respectively.

We obtain consumption, the net investment rate, hours, the Federal Funds rate, and inflation from the Federal Reserve Economic Database (FRED).[12] We follow Smets and Wouters (2007) in using the GDP deflator for inflation, constructing real consumption per capita, and non-farm business hours. Consumption and inflation are demeaned prior to estimation.

A possible concern is that the evidence presented in Figure 2 could indicate the presence of trends in the variables that we are interested in, namely concentration ratios and the rate of firm entry. Our model generates enough persistence endogenously to deal with these issues. The impulse responses presented earlier indicate that entry cost shocks generate persistent dynamics following transitory shocks. This persistence helps us match observed concentration ratios since 1989 using stationary structural shocks. The modal estimates of the persistence of the autoregressive processes all lie below 0.98 at quarterly frequency, which is less that the persistence estimated in most DSGE models.[13]

**Concentration Ratio** We link observed changes in the aggregate concentration ratio to changes in the model's aggregate Herfindahl index, which is simply the inverse of the number of firms $1/N_t$. To construct the aggregate measure of concentration, we build up from industry-level concentration ratios by first estimating import-adjusted concentration using sales from Compustat and imports provided by Peter Schott.[14] Import data are available

[12] The FRED codes and construction of the series are described in the Online Appendix.

[13] By way of comparison, the autoregressive parameters estimated in workhorse models like the model of Smets and Wouters (2007) can be very close to a value of 1 (see, for example, the estimates in Del Negro, Giannoni and Schorfheide, 2015).

[14] Available at http://faculty.som.yale.edu/peterschott/sub_international.htm.

by Harmonized System (HS)-code. HS codes are mapped to NAICS-6 industries using the concordance of Pierce and Schott (2012). We map NAICS codes to BEA segments, and aggregate to the industry-level.

We define the import-adjusted market share of a given Compustat firm $i$ that belongs to BEA industry $k$, as the ratio of firm sales to nominal gross output plus imports:[15]

$$s_{it}^k = \frac{\text{sale}_{it}^k}{\text{gross output}_{kt} + \text{imports}_{kt}}.$$

Concentration ratios sum market shares across the top firms, by sales, in a given industry.

We then aggregate concentration ratios using a nominal gross-output weighted average of industry-level concentration. Weighting by nominal output is appropriate in light of the model, but introduces some noise: the concentration ratio rises quickly in the late 2000's and then falls. This is because of large variation in the price of oil, and therefore the weight of the Nondurable Petroleum industry. Real output and the corresponding aggregate concentration ratio remain far more stable, and thus in our empirical exercises we hold the concentration ratio fixed after 2012. The concentration measure is available at an annual frequency, so we interpolate to obtain a quarterly series.

**Net Investment and Measured Q** The net investment rate is defined as the ratio of net investment to the lagged capital stock. Net investment is defined as gross fixed capital formation minus consumption of fixed capital, where the capital stock is defined as the sum of equipment, intellectual property, residential and non-residential structures.

Tobin's $Q$ for the non-financial corporate sector is measured in the data as

$$Q = \frac{V^e + (L - FA) - \text{Inventories}}{P_k K},$$

where $V^e$ is the market value of equity, $L$ are the liabilities, $FA$ are financial assets, and

[15] Because Compustat sales include exports, total sales in a given industry can exceed gross output plus imports. In that case, we define firm-level market share as the ratio of firm-sales to total Compustat sales.

$P_k K$ is the replacement cost of capital. Details of the data codes used to construct these measures, sourced from the Financial Accounts of the US, are provided in the Appendix.

**Expected ZLB Durations** We match the expected durations $\mathbf{d}_t$ (defined formally in Section 3.6) of the ZLB each quarter between 2009Q1 and 2015Q1 to the data in the New York Federal Reserve Survey of Primary Dealers, following Kulish, Morley and Robinson (2017). The Survey records a distribution of the expected length of time until lift-off from the ZLB. We use the mode of this distribution. In this series, the average expected duration was between 4 and 8 quarters from 2009Q1 to 2011Q2, and increased to between 9 and 12 quarters between 2011Q3 and 2013Q2, around the time that the Federal Reserve expanded its explicit calendar-based guidance.

### 5.3 Solution Method

A computational challenge we face is to approximate the dynamics of our model when the policy interest rate can be fixed at zero. Our solution method follows the piecewise linear approximation of Guerrieri and Iacoviello (2015), Kulish et al. (2017), and Jones (2017) which yields a time-varying reduced-form VAR approximation of the form

$$\mathbf{x}_t = \mathbf{J}_t + \mathbf{Q}_t \mathbf{x}_{t-1} + \mathbf{G}_t \epsilon_t. \tag{17}$$

To derive this approximation, we first denote the time-varying structural equations of the model as

$$\mathbf{A}_t \mathbf{x}_t = \mathbf{C}_t + \mathbf{B}_t \mathbf{x}_{t-1} + \mathbf{D}_t \mathbb{E}_t \mathbf{x}_{t+1} + \mathbf{F}_t \epsilon_t, \tag{18}$$

where $\mathbf{x}_t$ is the vector of the model variables and $\epsilon_t$ collects the shocks. The matrices $\mathbf{A}_t, \mathbf{B}_t, \mathbf{C}_t, \mathbf{D}_t$, and $\mathbf{F}_t$ contain the coefficients of the structural equations of the model, which are time-varying because of regime changes associated with the occasionally-binding ZLB.

That is, when the interest rate is positive, the structural equations of the model are

$$\mathbf{A}\mathbf{x}_t = \mathbf{C} + \mathbf{B}\mathbf{x}_{t-1} + \mathbf{D}\mathbb{E}_t\mathbf{x}_{t+1} + \mathbf{F}\epsilon_t, \tag{19}$$

while when the interest rate is at the ZLB, the structural equations become

$$\bar{\mathbf{A}}\mathbf{x}_t = \bar{\mathbf{C}} + \bar{\mathbf{B}}\mathbf{x}_{t-1} + \bar{\mathbf{D}}\mathbb{E}_t\mathbf{x}_{t+1} + \bar{\mathbf{F}}\epsilon_t. \tag{20}$$

Thus, under the ZLB system (20), the Taylor rule equation in (19) instead becomes $\tilde{r}_t = 0$.

For each period of the ZLB regime, we construct $\mathbf{J}_t$, $\mathbf{Q}_t$, and $\mathbf{G}_t$ by setting $\mathbf{A}_t, \mathbf{B}_t, \mathbf{C}_t, \mathbf{D}_t$, and $\mathbf{F}_t$ to the matrices in (19) and (20) in the periods they are conjectured to apply, and then use the recursion:

$$\begin{aligned}
\mathbf{Q}_t &= \left[\mathbf{A}_t - \mathbf{D}_t\mathbf{Q}_{t+1}\right]^{-1}\mathbf{B}_t \\
\mathbf{G}_t &= \left[\mathbf{A}_t - \mathbf{D}_t\mathbf{Q}_{t+1}\right]^{-1}\mathbf{F}_t \\
\mathbf{J}_t &= \left[\mathbf{A}_t - \mathbf{D}_t\mathbf{Q}_{t+1}\right]^{-1}\left[\mathbf{C}_t + \mathbf{D}_t\mathbf{J}_{t+1}\right].
\end{aligned}$$

The recursion is initialized with the solution of (19) in the period when the ZLB is expected to stop binding. In the notation of the expected duration of the lower bound regime, this is the reduced-form that is expected in period $\mathbf{d}_t + 1$. Thus, at each point in time that the ZLB binds, we assume that agents believe no shocks will occur in the future and iterate backwards through our model's equilibrium conditions from the conjectured lift-off date. Using (17), we form the state-space of our model and employ a Bayesian likelihood estimation.

## 5.4 Estimates

Table 2 presents moments of the prior and posterior distributions of the estimated parameters. The estimates of the monetary policy rule are presented in the first four rows of Table 2. The values of the coefficients are similar in magnitude to those estimated in other studies

Table 2: Moments of the Prior and Posterior Distributions of Estimated Parameters

| | Prior | | | | Posterior | | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Dist | Median | 10% | 90% | Mode | Median | 10% | 90% |
| $\phi_r$ | B | 0.7 | 0.6 | 0.9 | 0.75 | 0.75 | 0.71 | 0.78 |
| $\phi_p$ | N | 2.0 | 1.7 | 2.3 | 1.71 | 1.74 | 1.51 | 1.99 |
| $\phi_g$ | N | 0.2 | 0.1 | 0.3 | 0.14 | 0.14 | 0.04 | 0.25 |
| $\phi_y$ | N | 0.2 | 0.1 | 0.3 | 0.33 | 0.34 | 0.27 | 0.43 |
| $\rho_z$ | B | 0.5 | 0.2 | 0.8 | 0.98 | 0.98 | 0.97 | 0.98 |
| $\rho_b$ | B | 0.5 | 0.2 | 0.8 | 0.87 | 0.87 | 0.84 | 0.89 |
| $\rho_e$ | B | 0.5 | 0.2 | 0.8 | 0.82 | 0.82 | 0.78 | 0.85 |
| $\rho_q$ | B | 0.5 | 0.2 | 0.8 | 0.94 | 0.94 | 0.93 | 0.95 |
| $\rho_\kappa$ | B | 0.5 | 0.2 | 0.8 | 0.59 | 0.59 | 0.53 | 0.64 |
| $\rho_q^*$ | B | 0.5 | 0.2 | 0.8 | 0.86 | 0.86 | 0.82 | 0.90 |
| $100 \times \sigma_z$ | IG | 0.6 | 0.3 | 1.9 | 1.00 | 1.01 | 0.93 | 1.11 |
| $100 \times \sigma_b$ | IG | 0.6 | 0.3 | 1.9 | 0.19 | 0.19 | 0.16 | 0.24 |
| $100 \times \sigma_e$ | IG | 0.6 | 0.3 | 1.9 | 0.13 | 0.13 | 0.12 | 0.14 |
| $100 \times \sigma_q$ | IG | 0.6 | 0.3 | 1.9 | 0.12 | 0.13 | 0.11 | 0.15 |
| $100 \times \sigma_r$ | IG | 0.6 | 0.3 | 1.9 | 0.16 | 0.16 | 0.14 | 0.19 |
| $10 \times \sigma_\kappa$ | IG | 0.6 | 0.3 | 1.9 | 0.97 | 0.98 | 0.89 | 1.09 |
| $10 \times \sigma_q^*$ | IG | 0.6 | 0.3 | 1.9 | 0.88 | 0.87 | 0.79 | 0.96 |

Notes: The first four parameters are the parameters of the Taylor rule. The fifth to tenth parameters are the persistences of the shocks to technology, discount rate, price markup, risk premia, entry cost, and the measurement of $Q_t$. The remaining parameters are the corresponding standard deviations of those shocks, with $\sigma_r$ denoting the standard deviation of the monetary policy shock. B: beta distribution, N: normal distribution, IG: inverse-gamma distribution. The Online Appendix reports statistics regarding the convergence of the estimated posterior distributions across MCMC chains.

(see for example Justiniano, Primiceri and Tambalotti, 2010). The rest of Table 2 presents estimates of the persistence and size of the aggregate shock processes.

To interpret these estimates, we show the unconditional forecast error variance decompositions of a set of aggregate variables in Table 3. We find that the aggregate shocks to entry costs, TFP and to the valuation of corporate assets – risk premia shocks – are key drivers of aggregate variables. In reduced-form, the shock to the valuation of corporate assets has similar implications as the marginal efficiency of investment shocks that are found to be important for explaining business cycle fluctuations by Justiniano, Primiceri and Tambalotti (2010). As discussed in that paper, shocks to the marginal efficiency of investment, in the

Table 3: Unconditional Variance Decomposition of Aggregate Variables

| Variable \ Shock | Technology | Preference | Markup | Risk Premia | Policy | Entry Cost |
|---|---|---|---|---|---|---|
| Fed Funds Rate | 4 | 15 | 37 | 20 | 22 | 3 |
| $\Delta$ Consumption | 40 | 23 | 15 | 2 | 7 | 12 |
| Net Investment | 48 | 8 | 3 | 34 | 1 | 7 |
| Employment | 18 | 4 | 52 | 6 | 8 | 13 |
| Inflation | 8 | 22 | 11 | 29 | 20 | 10 |
| Herfindahl | 23 | 1 | 0 | 10 | 0 | 66 |
| Natural Rate | 4 | 24 | 0 | 20 | 0 | 52 |
| $V_t$ | 47 | 3 | 1 | 45 | 1 | 3 |

presence of frictions that drive an endogenous wedge between the marginal product of labor and the marginal rate of substitution, can generate the comovement of hours and consumption that is a feature of the data. We find that these risk premia shocks explain the bulk of the variation in the goods-producers' value $V_t$.

Aggregate entry cost shocks are found to explain about 13% of the variation of hours, 12% of the variation of the growth rate of consumption, more than half of the variation of the natural rate (about 52%), and two-thirds of the Herfindahl index (about 66%). As shown in counterfactual simulations in the final section, during our sample period 1989 to 2015, we find an important role for firm entry cost shocks in explaining investment, consumption, and the natural interest rate. Intuitively, similar to technology shocks, entry cost shocks can generate the comovement between consumption, hours, and investment observed. Finally, the variance decompositions for the levels of output, consumption, and investment are reported in the Online Appendix. Entry cost shocks account for just less than 20% of the unconditional variance of output and consumption, and 9% of investment. In their estimated model, Smets and Wouters (2007) report that productivity and markup shocks account for the bulk of output fluctuations in the long-run; in our model, entry cost shocks are an additional source of supply disturbances. Our use of data on concentration and profits is a powerful way to identify the shock in the data.

# 6 Firm Entry and Aggregate Dynamics

In this section, we use our estimated model to study the macroeconomic consequences of entry costs. We focus in particular on investment, output and real interest rates. In our main counterfactual, we set entry costs to zero from 2000 onwards in line with the evidence of Section (2), and we use the model to simulate the economy.

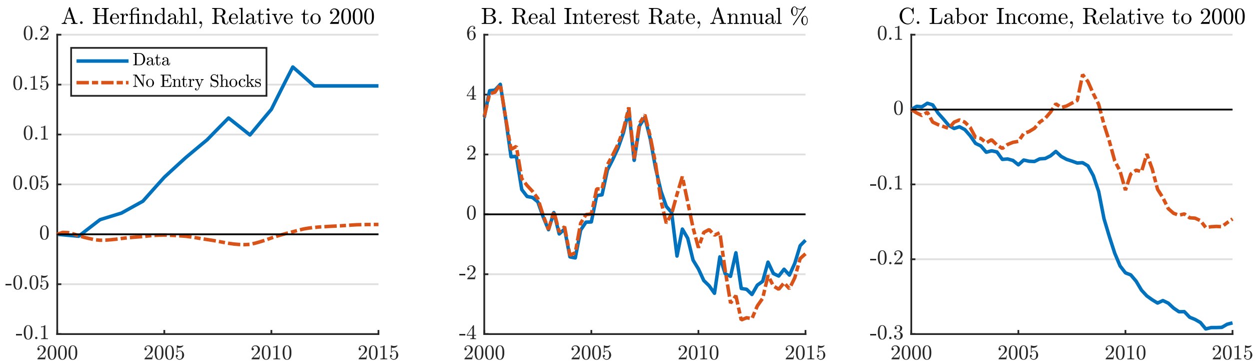
The first step in our approach is to obtain the structural shocks that generate the aggregate data using the Kalman filter, the data, and the solution (17).[16] With those shocks, we construct a counterfactual series by setting only the entry cost shocks only to zero from 2000Q1 on, keeping the other shocks at their estimated values. In computing the counterfactual series, we use the solution $\{\mathbf{J}_t, \mathbf{Q}_t, \mathbf{G}_t\}$ from (17). Under this approach, to compute the counterfactual, we use the same set of expected ZLB durations $\mathbf{d}_t$ as is used in the estimation. We show in the Appendix that our conclusions are similar if we were to instead allow the ZLB durations to respond endogenously to the estimated structural shocks and the change in the entry cost shocks.

Figure 4 plots the simulated paths of the Herfindahl, the real interest rate, and labor income without entry cost shocks. Panel A plots the Herfindahl index in the data and in the counterfactual. There is substantially more entry in the counterfactual without entry shocks and the simulated Herfindahl is almost 15% lower without entry cost shocks by the end of the sample. This shows that the dynamics of the Herfindahl are primarily driven by entry cost shocks in the model, as reflected in the variance decompositions in Table 3.

Panel B shows the impact that entry cost shocks have had on the annualized real interest rate. The model-implied real interest rate is shown in blue. The real interest fell from 3% in 2007Q3 to around -2% from 2010 onwards, following the reduction in the Federal Funds rate

[16] For this experiment, we keep the Herfindahl fixed at its 2012Q1 level from 2012Q1 on. This ensures our Herfindahl series is consistent with the patterns observed in Census data (available only until 2012), and mitigates the issues with relative prices and weights during the financial crisis, as documented in the Online Appendix. We also show in the Appendix that our implied series for entry rates matches the decline in entry rates observed in Census data and documented by a number of papers discussed in the Introduction. Furthermore, to obtain the model's estimated shocks, we use the sequence of expected ZLB durations that are used in the estimation.

Figure 4: Aggregate Counterfactual: Entry, Stance of Monetary Policy and Labor Income




to the ZLB and subsequent forward guidance policy.[17] The removal of entry cost shocks from 2000 onwards lowers inflation slightly before the ZLB binds. Outside the ZLB, this decline in inflation is easily accommodated by a lower Fed Funds rate, with essentially no impact on the real interest rate. During the ZLB period, however, the real interest increased by an average 1.3 percentage points between 2009Q1 and 2011Q2.[18] This reflects lower inflation in the counterfactual with more entry, which is not offset by monetary policy. From 2011Q3 onwards, inflation was higher and the real interest rate was lower in the counterfactual with more entry. Over this period, the lack of entry helps to explain lower inflation, constraining further the stance of monetary policy. These simulations illustrate the important role that firm entry has had in explaining movements in the real rate which are relevant for the operation of monetary policy over the ZLB period.

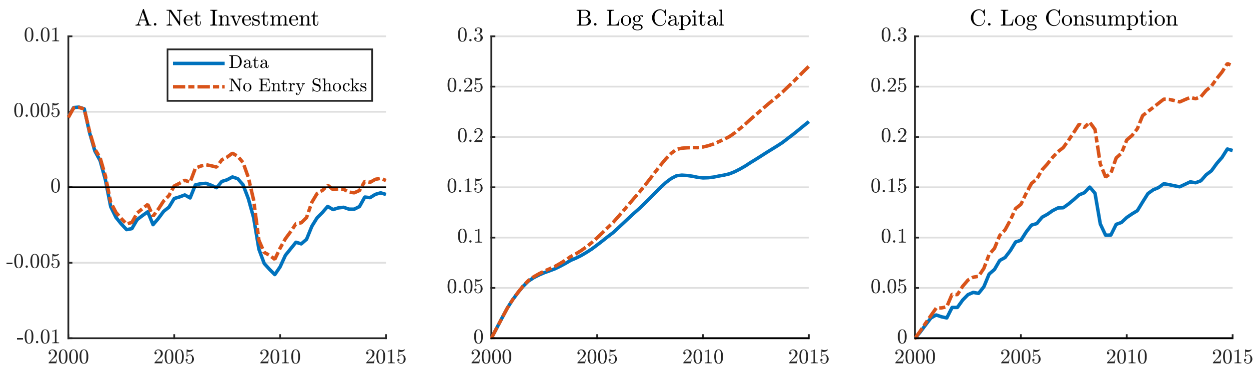
Entry costs have also had a large impact on labor income. In Panel C of Figure 4, we plot the filtered series for labor income against the counterfactual without entry shocks from 2000 onwards. In the counterfactual, labor income would have been higher throughout the period, and would have been about 15% higher by 2015. These observations suggest that entry cost shocks have had a significant impact on the labor share.

Next, we explore what our model predicts for investment and consumption – two ob-

[17]As we show in the Appendix, forward guidance policy pushed down the real interest rate by 1 percentage point on average during the ZLB regime.

[18]We show with additional results in the Appendix using counterfactuals without forward guidance that this amount is roughly the same as the contribution of forward guidance to lowering the real interest rate.

Figure 5: Counterfactuals of Capital and Consumption




servables that were used in estimation. Panel A of Figure 5 plots the net investment rate, while Panel B plots the log of the capital stock, and Panel C the log of consumption both in the data and in our two simulations. Without entry costs from 2000, the capital stock and consumption would be almost 5% and 8% higher, respectively, by 2015. We conclude that entry cost shocks have a significant effect on aggregate quantities.

# 7 Conclusions

We argue that entry costs shocks have played an important role in U.S. macroeconomic dynamics over the past 20 years. We estimate that entry costs have led to higher concentration, lower investment, lower labor income, and lower real interest rates.

We have used a highly stylized model of firm dynamics where the number of large firms is the only state variable needed to keep track of firms demographics. An important extension for future research is to study richer dimensions of heterogeneity across firms and industries.

Another important avenue for future research is to disentangle the role of different types of entry cost. In particular, one should consider separately the impact of administrative or regulatory costs; endogenous fixed cost à la Sutton (1991); and entry deterrence, including killer acquisitions (Cunningham et al., 2019).

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