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 and consumption by about 5%. Without entry costs the lower bound on the Federal Funds rate would have stopped binding two years earlier than it did.

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. (2017b) 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

[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.

changes in competition come from changes in entry costs. Most macroeconomic models, by 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 full Bayesian estimation of the model, thereby 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 10% lower by 2015 and the capital stock would have been about 4% higher. Absent these entry cost shocks, the real rate would have increased 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.

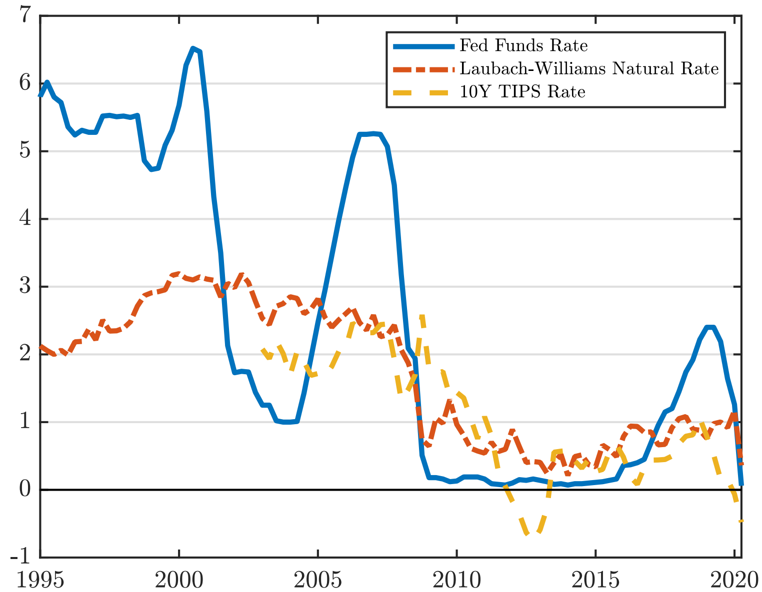
Literature. We estimate a general equilibrium model with time varying entry and competition, and an occasionally binding lower bound on interest rates. Our work therefore relates to three distinct lines of research. The first one is the literature on entry dynamics. Bernard et al. (2010) study the contribution of product creation and destruction to aggregate output. They 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. Davis and Haltiwanger (2019) emphasize the role of the housing market for explaining the decline. 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 a significant amount of 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) focuses on regulation and argues that "as a rule, regulation is acquired by the industry and is designed and operated primarily for its benefit." Sutton (1991, 1997) studies how incumbents use marketing and R&D to increase entry costs – and therefore limit the number of firms in an industry. 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%. Cacciatore et al. (2017) study the impact product market reforms at the ZLB. Lincoln and McCallum (2018) and Maggi and Felix (2019) study the effects of entry costs for international trade. Edmond et al. (2019) decompose the welfare costs of markups into misallocation across firms, inefficient entry, and an equivalent uniform output tax. 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 mark-ups. 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).

Following Eggertsson and Woodford (2003), a large literature has studied the consequences of a binding ZLB on the nominal rate of interest. The ZLB has been proposed as an explanation for the slow recovery of most major economies following the financial crisis of 2008-2009 (Summers, 2013). Eggertsson et al. (2019) 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 (see Fernández-Villaverde et al. 2015 for the exact properties of the New Keynesian model around the ZLB). Capital accumulation complicates matters, however, as consumption and investment can move in opposite directions.

Eggertsson et al. (2018), Corhay et al. (2018) and Kozeniauskas (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. Kozeniauskas (2018) uses a general equilibrium model of occupational choice to study the contribution of four explanations to the decline in entrepreneurship: changes in wages driven by skill-biased technical change; changes in technology facilitating the expansion of large firms; changes in fixed costs (which combine sunk entry costs and per-period operating costs); and changes in demographics. In line with our findings, he concludes that increasing fixed costs are the main explanation for the decline in entrepreneurship.

Figure 1: Interest Rates



Notes: Laubach Williams one-sided estimates from https://www.newyorkfed.org/research/policy/rstar. The real rate is the 10-Year Treasury Inflation-Indexed Security, Constant Maturity, Percent, Quarterly, Not Seasonally Adjusted (FRED code DFII10).

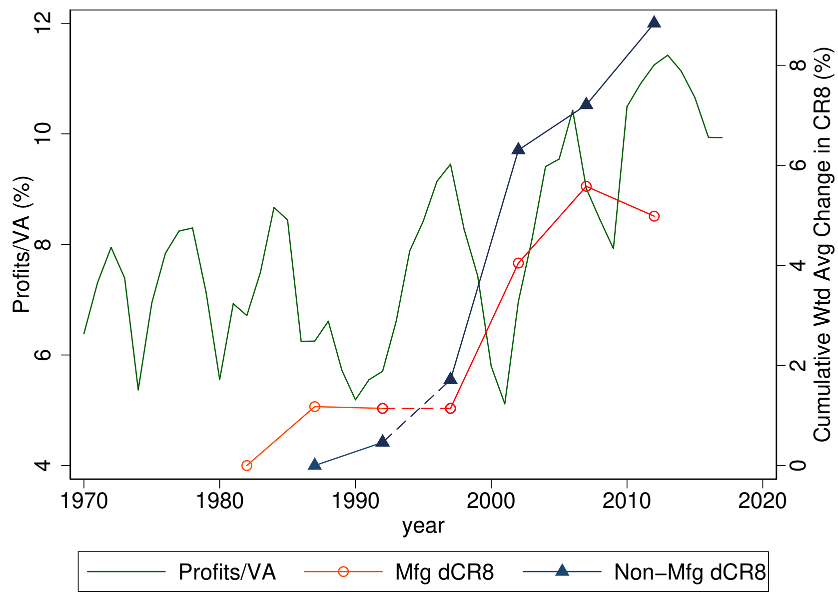
The paper proceeds as follows. Section 2 presents the relevant facts about the U.S. economy in recent decades. Section 3 presents our benchmark model. We start from a standard DSGE model in which we allow for the possibility that the ZLB constraint on short term nominal rates binds. Section 4 discusses the theoretical properties of entry shocks. Section 5 discusses how we solve our model and form its likelihood function, and Section 6 presents the aggregate implications of our model.

2 Four Facts About Interest Rates, Entry, Concentration, Profits and Investment

We begin with four stylized facts that guide our analyses.

Fact 1: Interest rates have fallen. We first document in Figure 1 that, as is well-known, real interest rates have fallen, as have estimates of the natural interest rate. The Federal Funds rate was at the zero lower bound between 2009 and 2015, and again from 2020.

Figure 2: Concentration and Profits



Notes: Solid line plots ratio of After Tax Corporate Profits with inventory valuation adjustment and capital consumption adjustment to Value Added for the U.S. Non-Financial Corporate sector (series W328RC1A027NBEA and NCBGVAA027S, respectively). Annual data from the Financial Accounts of the United States, via FRED. Dotted lines show the cumulated sales-weighted average change in 8-firm Concentration Ratio (CR8). Data from the U.S. Economic Census based on SIC codes before 1992 and NAICS codes after 1997. We include only those industries that are consistently defined over each 5-year period. Change from 1992 to 1997 imputed from Autor et al. (2017a) given the change in industry classification from SIC to NAICS. When multiple tax groups are reported, only taxable firms are included. CR8 equals the market share (by sales) of the 8 largest firms in each industry.

Fact 2: Profits and Concentration have Increased. Figure 2 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 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).

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

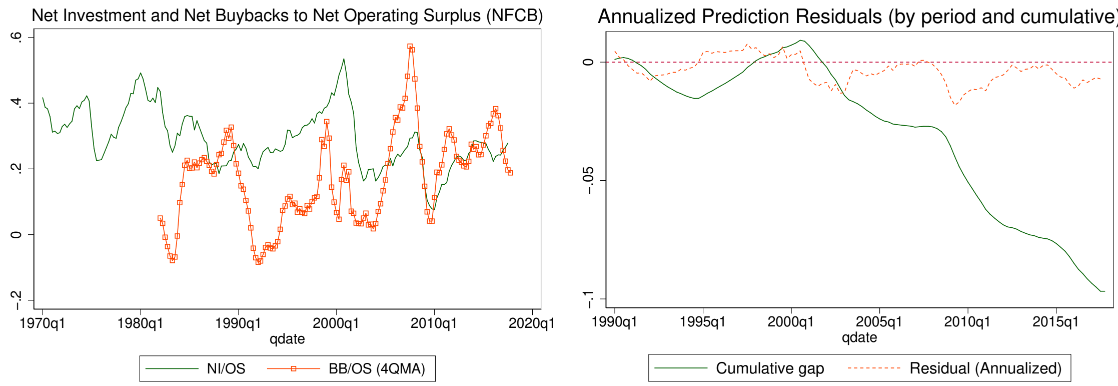
Figure 3: Firm Entry and Exit Rates

Source: Census BDS

Fact 4A: Investment is Low Relative to Profits and Q. The top chart in Figure 4 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 bottom 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. Figure 5 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

Figure 4: Net Investment, Profits and Q-Residuals



Notes: Quarterly data from the Financial Accounts of the United States, via FRED. Top plot shows the ratio of net investment and net buybacks to net operating surplus for U.S. Non Financial Corporate sector. Bottom plot shows the per-period and cumulative residuals of a regression of net investment for the U.S. Non Financial Business sector on Q for Non Financial Corporate sector. We use the 1990 to 2001 period as a training sample and use the estimated coefficients to forecast out-of-sample after 2001. See Appendix for additional details.

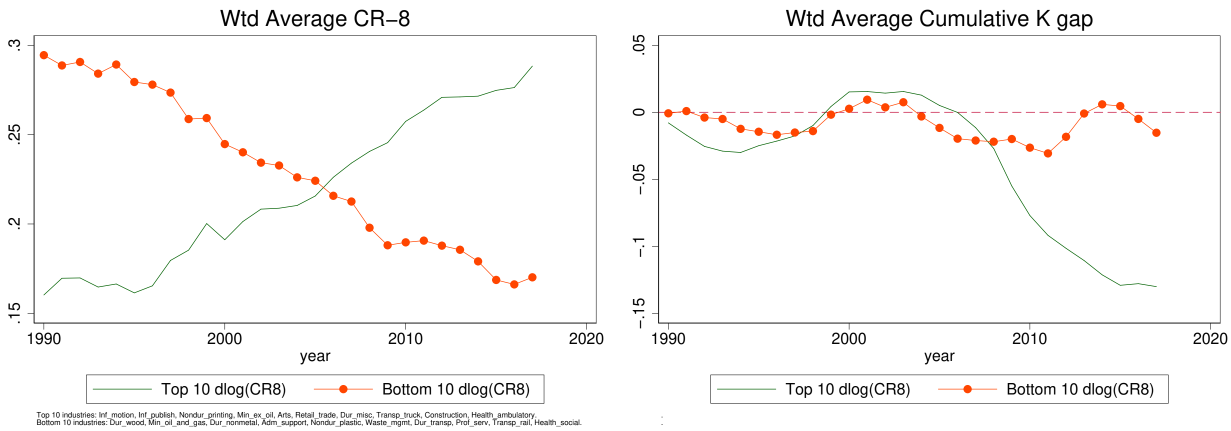
investment alongside concentration.

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 to produce goods and services.[3] The problem of capital producers who accumulate capital subject to convex adjustment costs to maximize market value gives rise to the Q-theory of investment, with net investment rising in line with Tobin's Q – the market value of the firm relative to the size of the capital stock. Goods-producers operate a Cobb-Douglas production function and face a price-setting problem under Calvo nominal rigidities, giving rise to a New Keynesian Phillips curve. The household sector is standard, with workers belonging to unions that face Calvo-style nominal wage rigidities. The shocks that drive aggregate dynamics are to productivity, the valuation of corporate assets, the

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

Figure 5: Cumulative Capital Gap for Concentrating and Non-Concentrating Industries



Notes: Annual data. Top plot shows the weighted average import adjusted 8-firm Concentration Ratio (CR8) for the 10 industries with the largest and smallest log-change in import-adjusted CR8 between 2000 and 2017. Bottom plot shows the cumulative implied capital gap (as a percent of capital stock) for the corresponding industries. See text for details.

Phillips curve, the household's discount factor, the monetary policy rule, and entry costs.

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 ϵ 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

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

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. Here we ignore intermediate inputs. The marginal cost χ_t is

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

Factor choices in the firm's problem imply the choice of capital and the composite good $h_{i,t}$ 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.[4] 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

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

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: $Y_t/N_t = y_t \left(N_t\right)^{\frac{1}{\epsilon-1}} > y_t$.

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 various modeling choices and found that the specific micro-foundation does not matter for the aggregate dynamics that we study. We therefore specify the markup directly as

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

The baseline NK model assumes $\phi_\mu = 0$. In our calibration with US data, we use $\phi_\mu \sim 0.3$. The shock ζ_t^μ is useful for two reasons. The first reason is the estimation of the model where we use a time series for inflation as in Smets and Wouters (2007). The second reason is that we can use this shock to study the macroeconomic impact of pure markup shocks.

3.3 Firm Entry

Firm entry plays an important role in our analysis. There are several notions of entry in the literature. In models of firms "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.[5] 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 δ_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 κ_t produced competitively industry with a convex cost function, so that the input price p_t^e is

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

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

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

decades. This assumption simplifies the aggregation of firms and allows us to explore complicated macro-economic dynamics. The main downside is that we cannot fully address the heterogeneity described in De Loecker et al. (2020).[6]

Free entry then requires that

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

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

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

where Div_t are real dividends. 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 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 at 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 κ_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, therefore they capture not only technological costs, but also administrative costs and regulatory barriers, and deterrence by incumbents.

Finally, when we map our model to the data we take into account that Tobin's Q reflects

[6] 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).

not only the usual capital adjustment costs but also monopolistic rents. Formally, we assume that there are capital providers, so that an industry's total Q combines the rents of goods-producers, which we denote by $\tilde{Q}_t$, and capital-producers Q_t^k, all measured at the end of the period

$$Q_t = Q_t^k + \frac{(1-\delta_n)\mathbb{E}_t\left[\Lambda_{t+1}V_{t+1}\right]}{P_t K_{t+1}}. \tag{12}$$

The elasticity of the number of entrants n_t to Q_t depends on the parameter ϕ_n. We discuss estimation later.

3.4 Investment

The capital providers are competitive, constant-return-to-scale firms. Capital accumulates as

$$K_{t+1} = (1-\delta)\, K_t + I_t. \tag{13}$$

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

$$x_t = \frac{1}{\phi_k}\left(Q_t^k - 1\right), \tag{14}$$

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

$$Q_t^k = \mathbb{E}_t\left[\Lambda_{t+1}\left(R_{t+1}^k + Q_{t+1}^k - \delta + \frac{1}{2\phi_k}\left(Q_{t+1}^k - 1\right)^2\right)\right]. \tag{15}$$

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 is completely standard and the details are in the Appendix.

3.5 Households

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

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{\ell_t^{1+\varphi}}{1+\varphi} \right) \right], \tag{16}$$

subject to the budget constraint

$$S_t + P_t C_t \leq \tilde{R}_t S_{t-1} + W_t \ell_t, \tag{17}$$

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

$$\Lambda_{t+j} = \beta^j \left(\frac{C_t}{C_{t+j}} \right)^{\gamma}. \tag{18}$$

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

$$\mathbb{E}_t \left[\Lambda_{t+1} \frac{P_t}{P_{t+1}} \tilde{R}_{t+1} \right] = 1. \tag{19}$$

Wage setting takes place as in the standard New Keynesian model (see Gali, 2008).

3.6 Shocks and Monetary Policy

To estimate the model with a Kalman filter we add shocks to all the observable equations. The entry cost shock ζ_t^{κ} was discussed earlier. A discount rate shock ζ_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 ζ_t^q helps us match time-varying expected returns and the volatility of the stock market relative to the bond market. All the shocks have an autoregressive structure. For instance, the risk premium shock is:

$$\zeta_t^q = \rho_q \zeta_{t-1}^q + \sigma_q \epsilon_t^q. \tag{20}$$

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

$$\tilde{r}_t^* = -\log(\beta) + \phi_i \tilde{r}_{t-1}^* + (1-\phi_i)\left(\phi_p \pi_t^p + \phi_y \left(\ln Y_t - \ln Y_t^F\right)\right) + \phi_g \ln\left(\frac{Y_t/Y_{t-1}}{Y_t^F/Y_{t-1}^F}\right) + \sigma_i \epsilon_t^i, \tag{21}$$

where π_t^p is price-level inflation, Y_t^F is the flexible price level of output, ϵ_t^i is a monetary policy shock, and the actual (log) short rate is constrained by the ZLB

$$\tilde{r}_t = \max(0; \tilde{r}_t^*). \tag{22}$$

At the ZLB, we allow for forward guidance as an extension of the ZLB duration beyond that implied by fundamentals, the shocks, and (22). That is, we allow, but do not impose, that the policy rate be extended beyond the duration implied by shocks, in line with the optimal policy prescription of Eggertsson and Woodford (2003) and Werning (2015). We discipline the expected lower bound durations with empirical measures, as discussed in the estimation section.

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" NK 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

$$\pi_t = \lambda \left(\mathtt{mc}_t - \phi_\mu \hat{n}_t + \zeta_t^\mu\right) + \beta \mathbb{E}_t \left[\pi_{t+1}\right], \tag{23}$$

where $\hat{n}_t \equiv \log\left(N_t/\bar{N}\right)$, and λ 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:

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

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

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

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 6 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 7). 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 cancelled by the increased future markup. Our model can therefore potentially explain a relatively mild inflation response to shocks that increase firms' market power.

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 a small set of key structural parameters, 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.[7] We set δ_n, the exogenous firm exit rate, to 0.09/4 to match the average annual exit rate of Compustat firms.[8] We calibrate the quarterly capital adjustment cost ϕ_k to a value of 20, in line with a regression across industries of net investment on Tobin's Q, with a full set of time and

[7] 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.

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

Figure 6: Pure Markup and Entry Shocks (model with exogenous markups, $\phi_\mu = 0$)

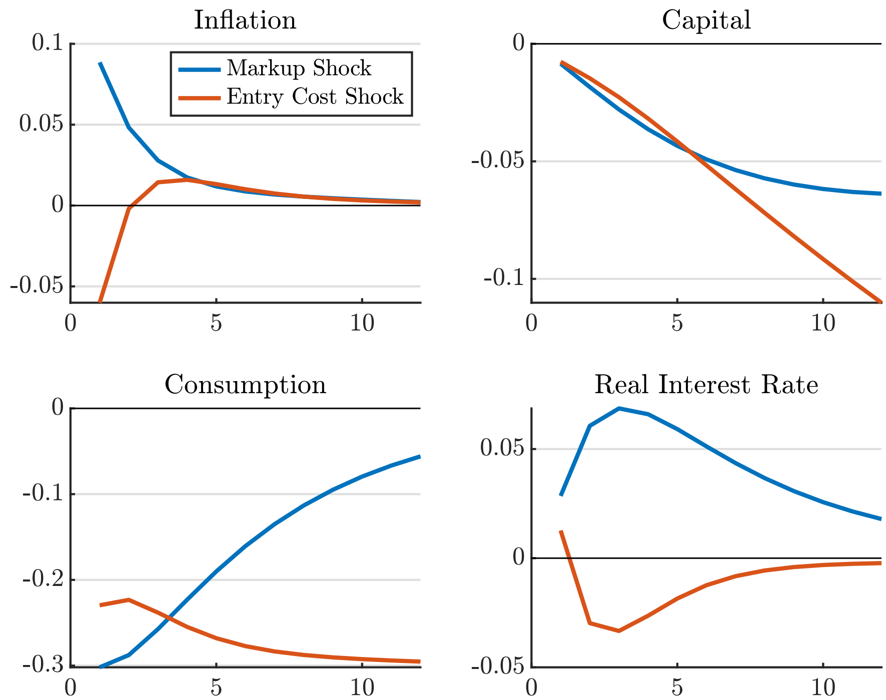


Figure 7: Entry Shocks with Endogenous Markups with $\phi_\mu = 1/3$

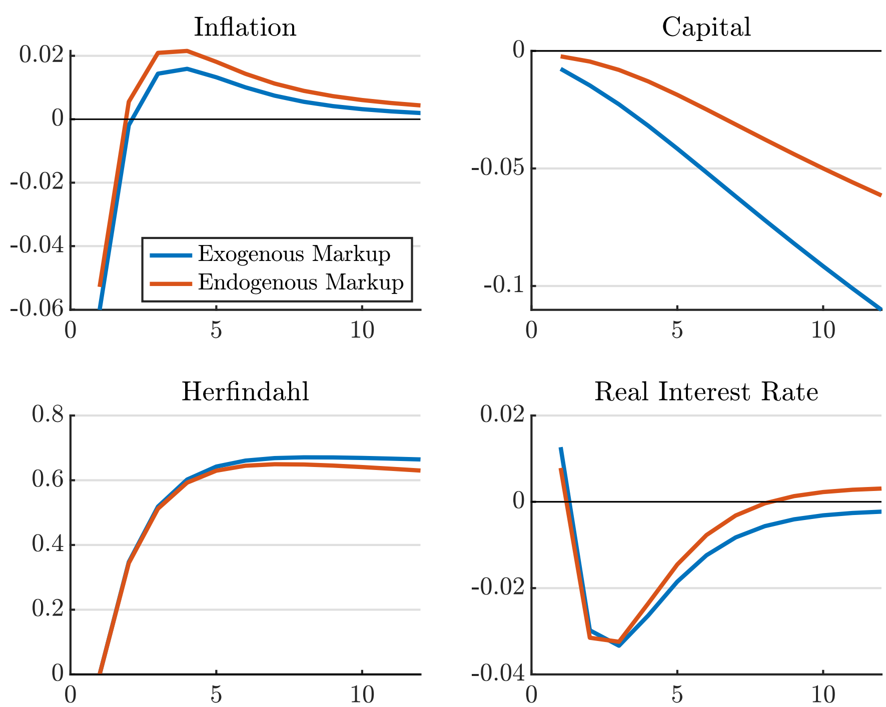


Table 1: Assigned Parameters

Parameter	Value	Description	Source/Target
ν	2	Inverse labor supply elasticity	
β	$0.97^{1/4}$	Discount factor	
θ_p	2/3	Price setting Calvo probability	Average price contract of 3Q
θ_p	3/4	Wage setting Calvo probability	Average wage contract of 4Q
ϕ_k	20	Capital adjustment cost	Industry regression of $x_{j,t}$ and $Q_{j,t}$
α	1/3	Capital share	
δ	0.025	Capital depreciation rate	
δ_n	0.09/4	Exogenous firm exit rate	Average annual % firm exit
ρ	0.5	EOS between $\ell_{i,y}$ and $m_{i,t}$	Edmond, Midrigan and Xu (2019)
ψ	0.6	Weight on labor in composite $h_{i,j,t}$	
ϵ	5	Industry substitution elasticity	Avg ${}^{\text{GOS}_j}/_{\text{Nominal Output}_j}$ in 1993

industry fixed effects.

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, while the level of concentration has increased by 25%.

One important parameter in our simulation is the elasticity of entry ϕ_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. Finally, we set ρ, the elasticity of substitution between labor and intermediate goods, to 0.5 as in Edmond, Midrigan and Xu (2019). 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:

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

where C_t is real consumption per capita, x_t is the net investment rate, ℓ_t is hours, $\tilde{r}_t$ is the Federal Funds rate, π_t is the inflation rate, 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 T_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 a measurement error to the observed Q_t.

We obtain consumption, the net investment rate, hours, the Federal Funds rate, and inflation from the Federal Reserve Economic Database (FRED). We follow Smets and Wouters (2007) in using the GDP deflator for inflation (FRED code GDPDEF), constructing real consumption per capita (FRED code PCEC divided by the GDPDEF, and the index of civilian non-institutional population CNP16OV),[9] and non-farm business hours (FRED code PRS85006023 times the civilian employment level CE16OV, divided by the index CNP16OV). Consumption and inflation are demeaned prior to estimation.

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 from Peter Schott's website. Import data are available by HS-code and year from 1989 to 2017. HS codes are mapped to NAICS-6 industries using

[9] We also smooth CNP16OV to account for jumps in the series.

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:[10]

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

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

We 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 in our main counterfactual.

Expected ZLB Durations. To discipline the expected durations of the ZLB between 2009Q1 and 2015Q1, we use data from the New York Federal Reserve Survey of Primary Dealers, following Kulish, Morley and Robinson (2017). The Survey provides 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 in line with the expansion of the Federal Reserve's explicit calendar-based guidance.

[10]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.

5.3 Solution Method

Zero Lower Bound. A key computational challenge we face is to approximate the dynamics of our model when the policy rule is subject to the ZLB. Our solution method follows that of Guerrieri and Iacoviello (2015) and Jones (2017) where we implement the ZLB as a time-varying sequence of Taylor rule parameters.

Denote the time-varying structural equations of the model as

$$\mathbf{A}_t \mathbf{x}_t = \mathbf{C}_t + \mathbf{B}_t \mathbf{x}_{t-1} + \mathbf{D}_t \mathbb{E}_t \mathbf{x}_{t+1} + \mathbf{F}_t \epsilon_t, \tag{24}$$

where $\mathbf{x}_t$ is the vector of state variables and ϵ_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 the ZLB causes the Taylor rule equation to change to $\tilde{r}_t = 0$. Our goal is to construct the reduced-form VAR approximation of the form

$$\mathbf{x}_t = \mathbf{J}_t + \mathbf{Q}_t \mathbf{x}_{t-1} + \mathbf{G}_t \epsilon_t. \tag{25}$$

When the ZLB binds, we construct $\mathbf{J}_t$, $\mathbf{Q}_t$, and $\mathbf{G}_t$ with the following recursion:

$$\mathbf{Q}_t = \left[\mathbf{A}_t - \mathbf{D}_t \mathbf{Q}_{t+1}\right]^{-1} \mathbf{B}_t \tag{26}$$

$$\mathbf{G}_t = \left[\mathbf{A}_t - \mathbf{D}_t \mathbf{Q}_{t+1}\right]^{-1} \mathbf{F}_t \tag{27}$$

$$\mathbf{J}_t = \left[\mathbf{A}_t - \mathbf{D}_t \mathbf{Q}_{t+1}\right]^{-1} \left[\mathbf{C}_t + \mathbf{D}_t \mathbf{J}_{t+1}\right] \tag{28}$$

That is, we construct the sequence of structural equations in the matrices of (24) and iterate backwards from the matrices of the final reduced form when the ZLB is expected to stop binding. 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. When we do not know the expected ZLB duration, we can iterate on the periods that the interest rate is conjectured to be in effect until it converges and the ZLB constraint is satisfied, after which the solution is that in (25). With (25), 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 (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.[11] To interpret these, 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 key drivers of business cycles in Justiniano, Primiceri and Tambalotti (2010). As discussed in that paper, shocks to the marginal efficiency of investment, in the 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 goods-producers' Q (denoted by $\tilde{Q}_t$).

Aggregate entry cost shocks are found to explain, at the 8 quarter horizon, about 12% of the variation of employment hours, 18% of the variation of output, and a significant amount of the variation of the natural rate (about 58%) and most of the Herfindahl index (about 98%). Unconditionally, the Herfindahl and the number of firms in the economy in our model is largely explained by technology shocks (26%), risk premia shocks (11%), and

[11] We note that the modal estimates of the autoregressive processes are all below 0.98, suggesting that our model generates sufficient persistence to explain slow-moving and persistent variables such as concentration ratios. Indeed, 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 et al., 2015).

Table 2: Estimated Parameters

	Prior				Posterior			
Parameter	Dist	Median	10%	90%	Mode	Median	10%	90%
ϕ_r	B	0.7	0.6	0.9	0.782	0.782	0.748	0.810
ϕ_p	N	2.0	1.7	2.3	1.716	1.739	1.501	1.985
ϕ_g	N	0.2	0.1	0.3	0.128	0.127	0.041	0.222
ϕ_y	N	0.2	0.1	0.3	0.332	0.346	0.275	0.427
ρ_z	B	0.5	0.2	0.8	0.979	0.979	0.973	0.984
ρ_b	B	0.5	0.2	0.8	0.861	0.861	0.833	0.887
ρ_e	B	0.5	0.2	0.8	0.831	0.820	0.784	0.849
ρ_q	B	0.5	0.2	0.8	0.941	0.939	0.925	0.952
ρ_κ	B	0.5	0.2	0.8	0.578	0.572	0.515	0.625
ρ_q^*	B	0.5	0.2	0.8	0.873	0.863	0.826	0.895
$100 \times \sigma_z$	IG	0.6	0.3	1.9	0.981	0.994	0.913	1.086
$100 \times \sigma_b$	IG	0.6	0.3	1.9	0.185	0.193	0.158	0.234
$100 \times \sigma_e$	IG	0.6	0.3	1.9	0.125	0.127	0.115	0.142
$100 \times \sigma_q$	IG	0.6	0.3	1.9	0.126	0.128	0.109	0.151
$100 \times \sigma_i$	IG	0.6	0.3	1.9	0.149	0.150	0.133	0.171
$10 \times \sigma_\kappa$	IG	0.6	0.3	1.9	0.975	0.978	0.888	1.084
$10 \times \sigma_q^*$	IG	0.6	0.3	1.9	0.842	0.841	0.769	0.924

entry cost shocks (63%). We also find that entry cost shocks explain, at the infinite horizon, an important fraction of the variation in hours (12%), aggregate output (16%), consumption (16%), inflation (9%), and the natural rate (52%). 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 present in the data, as well as comovement between inflation and the Fed Funds rate, while the use of data on concentration and profits is a powerful way to identify the shock in the data.

Table 3: Variance Decomposition of Aggregate Variables

Shock / Variable	Technology	Preference	Phillips Curve	Risk Premia	Policy	Entry Cost
A. 8 Quarter Horizon						
Fed Funds Rate	0.5	13.0	40.4	19.2	25.9	1.0
Output	78.4	0.3	1.9	1.0	0.3	18.1
Consumption	59.7	6.9	10.5	2.0	1.3	19.5
Net Investment	37.7	8.9	3.3	44.1	2.2	3.8
Employment	15.1	4.7	54.6	5.0	8.4	12.3
Inflation	6.5	20.7	9.8	30.8	23.1	9.0
Herfindahl	0.2	0.1	0.0	1.3	0.0	98.4
Natural Rate	0.0	24.1	0.0	17.5	0.0	58.4
$\tilde{Q}_t$	6.4	2.8	0.3	72.3	2.1	16.1
Dividends	2.4	4.6	68.7	5.0	7.8	11.5
B. Unconditional						
Fed Funds Rate	3.6	12.0	37.3	21.7	21.9	3.4
Output	76.5	0.4	0.3	7.2	0.1	15.6
Consumption	75.3	1.3	1.4	6.0	0.2	15.9
Net Investment	47.4	5.9	2.3	36.7	1.3	6.3
Employment	16.9	4.3	52.2	6.6	7.8	12.2
Inflation	6.4	20.2	9.8	32.3	21.9	9.3
Herfindahl	25.7	0.6	0.2	10.8	0.0	62.7
Natural Rate	3.7	23.0	0.0	21.7	0.0	51.6
$\tilde{Q}_t$	5.7	1.8	4.3	56.7	1.6	29.9
Dividends	2.2	5.5	54.3	9.7	6.0	22.2

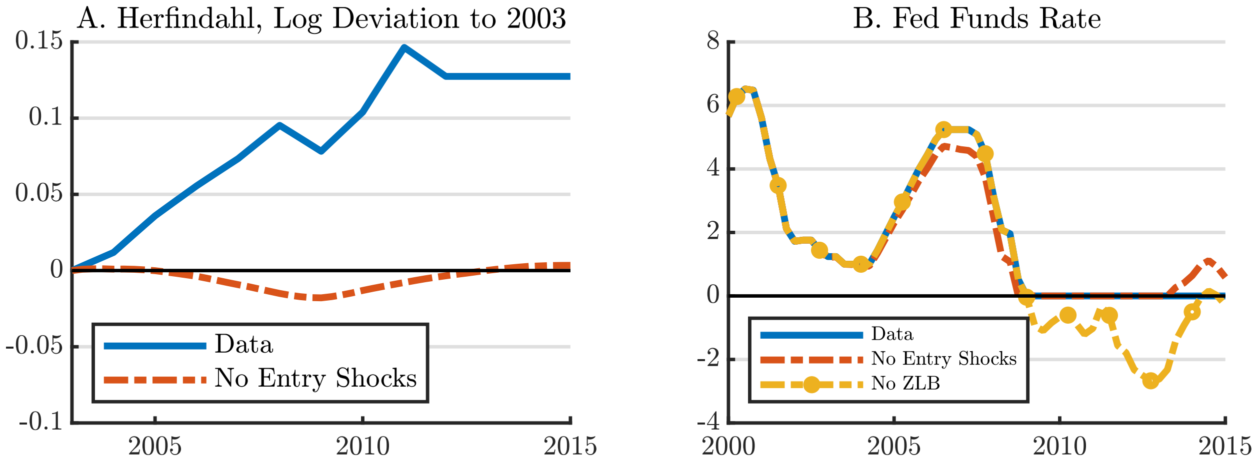
6 Firm Entry and Aggregate Dynamics

In this section, we use our estimated model to study the macroeconomic consequences of entry costs. We focus in particular on investment, output and monetary policy. In our main counterfactual, we set entry costs to zero from 2003 onwards and we use the model to simulate the economy. 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 10% lower by 2015 and the capital stock would have been about 4% higher.

The first step in our approach is to obtain the smoothed shocks that generate the aggregate data.[12] With those shocks, we construct counterfactual series by setting the entry cost shocks to zero from 2003Q1 on. The presence of the occasionally binding ZLB during 2009 to 2015 complicates the interpretation of this counterfactual because, in practice, the ZLB can be binding because of the shocks themselves (including the entry cost shock) or because of monetary policy actions taken during this period (which could also be in response to the effects of entry cost shocks). For this reason, in assessing the effect of entry cost shocks, we construct two comparable counterfactual series: (i) a counterfactual where we remove the contribution of stimulatory forward guidance during the ZLB period, and (ii) a counterfactual with entry cost shocks set to zero from 2003 onwards and the nominal interest rate subject to the occasionally binding ZLB. Our approach to removing the contribution of forward guidance is to allow the ZLB durations to react endogenously to the identified shocks; the difference between these endogenous durations and the durations used in the estimation (and in deriving the shocks) quantifies the extent of lower-for-longer forward guidance at

[12] 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 8: Aggregate Counterfactual, Entry and Monetary Policy

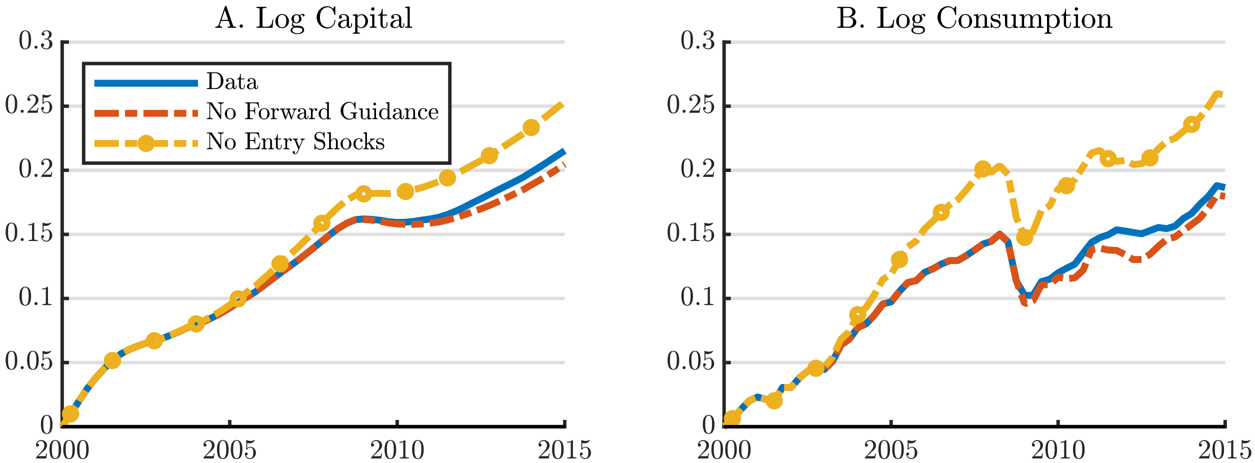


each point in time.

Figure 8 plots the simulated paths of the Herfindahl and the Fed Funds rate 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 about 10% lower without entry cost shocks by the end of the sample. The entry cost shocks are thus responsible for about two-fifths of the overall increase in entry. Panel B shows that the Fed Funds rate would have lifted off by the second half of 2013 without entry costs. Panel B also shows the path of the Fed Funds rate if we take away the ZLB constraint. The ZLB seems to be a significant constraint on monetary policy, particularly around 2013 where we estimate that the Fed would have lowered the rate by over 2 percentage points in 2013. This observation is consistent with estimates of the shadow interest rate from, for example, Wu and Xia (2016).

Next, we explore what our model predicts for investment and consumption. Panel A of Figure 9 plots the log of the capital stock, and panel B the log of consumption both in the data and in our two simulations. Without entry costs, the capital stock and consumption would be almost 3% and 6% higher, respectively, by 2015. We conclude that entry cost shocks have a significant effect on aggregate quantities and that modeling monetary policy

Figure 9: Counterfactuals of Capital and Consumption



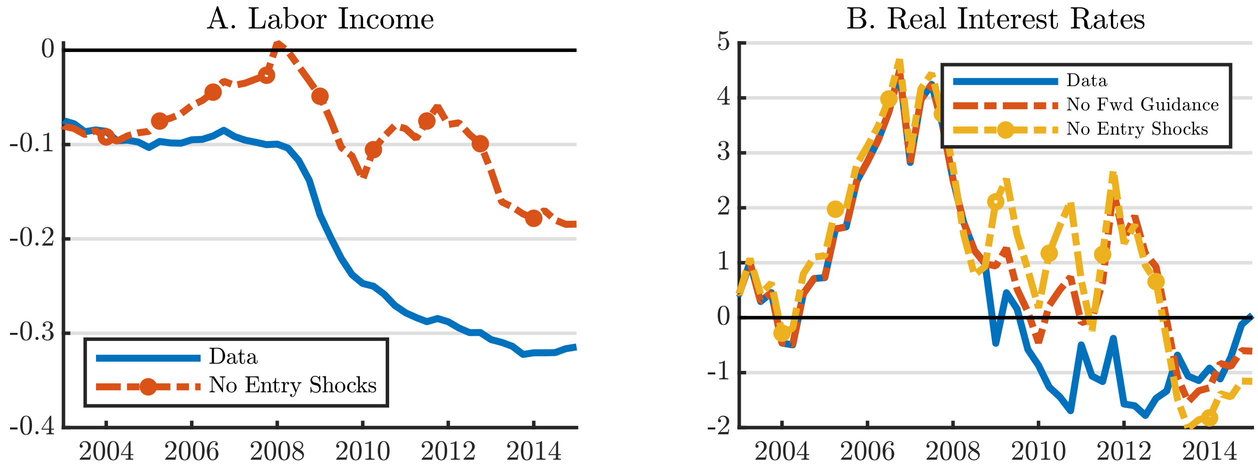
during the ZLB is crucial to determine the aggregate effects of these shocks.[13]

Entry costs and the trend increase in markups also have a large impact on labor income and on the real interest rate. In Figure 10, we plot the filtered series for labor income against the counterfactual without entry shocks from 2003 onwards and without forward guidance during the ZLB period. In the counterfactual, labor income would have been higher throughout the period from 2003, and would have been about 12% higher by 2015. These observations suggest that entry cost shocks have had a significant impact on the labor share.

We next explore the impact that entry cost shocks have had on the real interest rate. In the right panel of Figure 10, we plot in blue the model implied real interest rate along with two counterfactual paths paths for the real interest rate. The red path shows the real interest rate without forward guidance stimulus and with all shocks. Under this path, the real interest rate falls to around 0% in 2010, roughly 0.5 percentage points higher than implied by the model. The yellow line shows the counterfactual real interest rate when entry cost shocks and forward guidance are removed. Absent these entry cost shocks, the real rate would have

[13]Removing forward guidance causes the level of capital to fall by 0.6 percentage points by 2012 and by 1.1 percentage points by 2015. For consumption, removing forward guidance causes consumption to fall by 1.6 percentage points by 2012, and by 0.7 percentage points by 2015 as the forward guidance stimulus unwinds.

Figure 10: Labor Income and the Real Interest Rate



increased 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.[14] These simulations illustrate the important role that firm entry has had in explaining movements in the real rate and in providing a drag on the operation of monetary policy over the ZLB period.

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

[14]Towards the end of the sample, the real interest rate without entry cost shocks falls slightly below the series computed without forward guidance. This situation arises from the small decrease in measured concentration in 2012, implying a small reversal in estimated entry costs.

killer acquisitions (Cunningham et al., 2019).

References

Akcigit, Ufuk and Sina Ates, "What Happened to U.S. Business Dynamism?," Technical Report, NBER Working Paper 2019.

Autor, David, David Dorn, Lawrence F. Katz, Christina Patterson, and John Van Reenen, "The Fall of the Labor Share and the Rise of Superstar Firms," 2017.

_ , _ , Lawrence Katz, Christina Patterson, and John Van Reenen, "Concentrating on the Fall of the Labor Share," *AER Papers and Proceedings*, 2017, *107* (5), 180–185.

Barkai, Simcha, "Declining Labor and Capital Shares," 2017. University of Chicago.

Basu, Susanto, "Are Price-Cost Mark-ups Rising in the United States? A Discussion of the Evidence," 2019.

Bergin, Paul R., Ling Feng, and Ching-Yi Lin, "Firm Entry and Financial Shocks," *The Economic Journal*, apr 2017, *128* (609), 510–540.

Bernard, Andrew B., Stephen J. Redding, and Peter K. Schott, "Multiple-Product Firms and Product Switching," *American Economic Review*, March 2010, *100* (1), 70–97.

Bilbiie, Florin, Fabio Ghironi, and Marc Melitz, "Monopoly Power and Endogenous Variety in Dynamic Stochastic General Equilibrium: Distortions and Remedies," 2006.

_ , _ , and _ , "Monetary Policy and Business Cycles with Endogenous Entry and Product Variety," 2008. NBER Macroannuals.

_ , _ , and _ , "Endogenous Entry, Product Variety, and Business Cycles," *Journal of Political Economy*, 2012, *120* (2), 304–345.

Cacciatore, Matteo and Giuseppe Fiori, "The Macroeconomic Effects of Goods and Labor Marlet Deregulation," *Review of Economic Dynamics*, April 2016, *20*, 1–24.

__ , **Romain Duval, Giuseppe Fiori, and Fabio Ghironi**, "Market Reforms at the Zero Lower Bound," 2017.

Cavenaile, Laurent, Murat Alp Celik, and Xu Tian, "Are Markups Too High? Competition, Strategic Innovation, and Industry Dynamics," 2020.

CEA, "Benefits of Competition and Indicators of Market Power," Issue Brief April 2016.

Corhay, Alexandre, Howard Kung, and Lukas Schmid, "Q: Risk, Rents, or Growth?," Technical Report 2018.

Covarrubias, Matias, Germán Gutiérrez, and Thomas Philippon, "From Good to Bad Concentration?U.S. Industries over the past 30 years," *NBER Macroannuals*, 2019.

Crouzet, Nicolas and Janice Eberly, "Intangibles, Investment, and Efficiency," *AEA Papers and Proceedings*, 2018.

Cunningham, Colleen, Florian Ederer, and Song Ma, "Killer Acquisitions," 2019.

Davis, Steven J and John C Haltiwanger, "Dynamism diminished: The role of housing markets and credit conditions," Technical Report, National Bureau of Economic Research 2019.

Decker, Ryan A., John Haltiwanger, Ron S. Jarmin, and Javier Miranda, "Where Has All the Skewness Gone? The Decline in High-Growth (Young) Firms in the U.S," Working Papers 15-43, Center for Economic Studies, U.S. Census Bureau November 2015.

Decker, Ryan, John Haltiwanger, Ron Jarmin, and Javier Miranda, "The Secular Decline in Dynamism in the U.S.," 2014. mimeo.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu, "How Costly Are Markups?," 2019.

Eggertsson, Gauti and Michael Woodford, "The Zero Bound on Interest Rates and Optimal Monetary Policy," *Brookings Papers on Economic Activity*, 2003, *1*, 139–234.

Eggertsson, Gauti B., Jacob A. Robbins, and Ella Getz Wold, "Kaldor and Piketty's Facts: The Rise of Monopoly Power in the United States," Working Paper 24287, National Bureau of Economic Research February 2018.

_ , Neil R. Mehrotra, and Jacob A. Robbins, "A Model of Secular Stagnation: Theory and Quantitative Evaluation," *American Economic Journal: Macroeconomics*, 2019.

Feenstra, Robert C. and David E. Weinstein, "Globalization, Markups and U.S. Welfare," *Journal of Political Economy*, 2017.

Fernández-Villaverde, Jesús, Grey Gordon, Pablo Guerrón-Quintana, and Juan F. Rubio-Ramírez, "Nonlinear adventures at the zero lower bound," *Journal of Economic Dynamics and Control*, 2015, *57*, 182–204.

Furman, Jason, "Business Investment in the United States: Facts, Explanations, Puzzles, and Policies," 2015.

Gali, Jordi, *Monetary Policy, Inflation, and the Business Cycle*, Princeton University Press, 2008.

Grullon, Gustavo, Yelena Larkin, and Roni Michaely, "Are US Industries Becoming More Concentrated?," *Review of Finance*, 2019.

Guerrieri, Luca and Matteo Iacoviello, "OccBin: A Toolkit for Solving Dynamic Models With Occasionally Binding Constraints Easily," *Journal of Monetary Economics*, 2015, pp. 23–38.

Gutiérrez, Germán and Thomas Philippon, "Investment-less Growth: An Empirical Investigation," *Brookings Papers on Economic Activity*, 2017, *Fall.*

— and — , "The Failure of Free Entry," 2019.

— and — , "Some Facts about Dominant Firms," 2020. NBER WP.

Hopenhayn, Hugo, "Entry, Exit, and firm Dynamics in Long Run Equilibrium," *Econometrica*, 1992, *60* (5), 1127–1150.

Impullitti, Giammario, Omar Licandro, and Pontus Rendahl, "Technology, market structure and the gains from trade," 2017.

Jaef, Roberto N. Fattal and Jose Ignacio Lopez, "Entry, trade costs, and international business cycles," *Journal of International Economics*, nov 2014, *94* (2), 224–238.

Jones, Callum, "Unanticipated Shocks and Forward Guidance at the Zero Lower Bound," 2017. mimeo NYU.

— , Germán Gutiérrez, and Thomas Philippon, "Entry Costs and Industry Dynamics," 2020.

Jovanovic, Boyan, "Selection and Evolution of Industry," *Econometrica*, 1982, *50*, 649–670.

Justiniano, Alejandro, Giorgio Primiceri, and Andrea Tambalotti, "Investment Shocks and the Business Cycle," *Journal of Monetary Economics*, 2010, *57*, 132–145.

Kimball, Miles, "The Quantitative Analytics of the Basic Neomonetarist Model," *Journal of Money, Credit and Banking*, 1995, *27* (4), 1241–77.

Kozeniauskas, Nicholas, "What's Driving the Decline in Entrepreneurship?," 2018.

Kulish, Mariano, James Morley, and Timothy Robinson, "Estimating DSGE Models with Zero Interest Rate Policy," *Journal of Monetary Economics*, 2017, *88*, 35–49.

Lee, Yoonsoo and Toshihiko Mukoyama, "A model of entry, exit, and plant-level dynamics over the business cycle," *Journal of Economic Dynamics and Control*, nov 2018, *96*, 1–25.

Lincoln, William F. and Andrew H. McCallum, "The rise of exporting by U.S. firms," *European Economic Review*, feb 2018, *102*, 280–297.

Loecker, Jan De, Jan Eeckhout, and Gabriel Unger, "The Rise of Market Power and the Macroeconomic Implications*," *The Quarterly Journal of Economics*, 01 2020, *135* (2), 561–644.

Loualiche, Erik, "Asset Pricing with Entry and Imperfect Competition," 2016.

Maggi, Chiara and Sonia Felix, "What is the Impact of Increased Business Competition?," 2019.

Negro, Marco Del, Marc Giannoni, and Frank Schorfheide, "Inflation in the Great Recession and New Keynesian Models," *American Economic Journal: Macroeconomics*, 2015, *7* (1), 168–196.

Pierce, Justin R. and Peter K. Schott, "A concordance between ten-digit U.S. Harmonized System codes and SIC/NAICS product classes and industries," 2012.

Smets, Frank and Rafael Wouters, "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," *American Economic Review*, June 2007, *97* (3), 586–606.

Stigler, George J., "The Theory of Economic Regulation," *Bell Journal of Economics*, 1971, *3* (21).

Summers, Lawrence H., "Why Stagnation Might Prove to be the New Normal," 2013. Financial Times.

Sutton, John, *Sunk Costs and Market Structure* 1991.

—, "Gibrat's Legacy," *Journal of Economic Literature*, 1997, *35* (1).

Swanson, Eric and John Williams, "Measuring the Effect of the Zero Lower Bound on Medium- and Longer-Term Interest Rates," *American Economic Review*, 2014, *104*, 3154–3185.

Syverson, Chad, "Macroeconomics and Market Power: Facts, Potential Explanations, and Open Questions," Technical Report, Brookings Economic Studies January 2019.

Werning, Ivan, "Incomplete Markets and Aggregate Demand," 2015. Working Paper.

Wu, Jing Cynthia and Fan Dora Xia, "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound," *Journal of Money, Credit, and Banking*, 2016, *48* (2-3), 253–291.