The Secular Stagnation of Investment?

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PRELIMINARY

Abstract

We argue that a secular decline in competition in the goods markets explains several macroeconomic puzzles, in particular low interest rates and weak corporate investment. Corporate investment in the U.S. is lower than what one would expect based on profitability, discount rates, or the market value of corporate assets (Q-theory). Moreover, this investment gap is driven by firms located in less competitive industries. We explore the macro-economic consequences of this phenomenon in a DSGE model with time-varying parameters and an occasionally binding zero lower bound constraint on nominal interest rates (ZLB). We calibrate the model using micro data on investment and we show that the trend decrease in competition can explain the joint evolution of investment, Q, and the nominal interest rate. Absent the decrease in competition, we find that the U.S. economy would have escaped the ZLB by the end of 2010 and that the nominal rate today would be close to 2%.

In December 2008, the Federal Reserve lowered the federal funds rate to a target range of zero to 25 basis points. The U.S. economy has remained stuck at or near this zero lower bound (ZLB) on nominal rate of interest rates ever since. Our goal in this paper is to shed some light on why this has happened.

Gutiérrez and Philippon (2016) show that investment is weak relative to measures of profitability and valuation – particularly Tobin's Q, and that this weakness starts in the early 2000's. Gutiérrez and Philippon (2016) find that lack of competition explains the bulk of the investment gap across industries and across firms. Industries with less entry and more concentration invest less, even after controlling for current market conditions. Within each industry-year, the investment gap is driven by firms that are owned by quasi-indexers and located in industries with less entry/more concentration. These firms spend a disproportionate amount of free cash flows buying back their shares.

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The main contribution of our paper is to study the macro-economic consequences of a decline in competition in the markets for goods and services. We argue that it accounts for the decrease in investment, the persistence of the ZLB problem, and, to some extent, the decreased in the labor share.

Section 1 presents the relevant facts about the U.S. economy in recent years. Section 2 presents our benchmark model. We start from a standard DSGE model in which we allow for the possibility that the zero lower bound constraint on short term nominal rates binds. The most important feature of our model is a time-varying degree of competition in the goods market. The rational expectation equilibrium of the model is then represented by the time-varying function $x_t = \Psi_t(x_{t-1}, \mathbb{E}_t x_{t+1}, \epsilon_t)$, where x represents the state and ϵ the shocks.

An empirical contribution of our paper is that we construct an observable time series for the degree of competition that we feed in the model. Competition is not a residual that we obtain after fitting the macroeconomic data. It is an observable input that parameterizes the function Ψ_t above.

We solve for the path of the economy using the solution method and approach of Jones (2016). We use a Kalman filter and information about expected duration of the ZLB to back out the other shocks that drive the model (productivity, discount rate, risk premia). Our main finding is that time-varying competition has had a significant impact on macro-economic dynamics over the past 30 years. For instance, absent the decrease in competition since 2000, the nominal interest rate would have been just below 2 per cent per annum in 2015.

Literature A large and growing literature studies the consequences of a binding zero lower bound (ZLB) on the nominal rate of interest. Krugman (1998) and Eggertsson and Woodford (2003) argue that the ZLB can lead to a large drop in output. Lawrence Christiano (2011) show that the government spending multiplier can be large when the ZLB binds, suggesting a more important role for fiscal policy. Coibion et al. (2012) ask whether the risk of a binding ZLB should lead policy makers to increase the average rate of inflation. Swanson and Williams (2014) study the impact of the ZLB on long rates, that are more relevant for economic decisions.

Most studies of the liquidity trap are based on simple New-Keynesian models that abstract from capital accumulation. Fernández-Villaverde et al. (2015) study the exact properties of the New Keynesian model around the ZLB. In these models, consumption is depressed because the equilibrium interest rate is higher than the natural rate – the rate that would have cleared the asset market in the absence of price or wage rigidities. In most of the existing models, the ZLB episode is triggered by an increase in households' patience, that is, an increase in their subjective discount factor. Explicitly allowing for capital accumulation complicates matters, however, because changes in discount rates imply that consumption and investment move in opposite directions. The shock that triggers the ZLB episode is also a shock that reduces the real rate, and therefore encourages investment.

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) argues that the natural rate of interest

Table 1: Current Account of Non financial Sector

Name	Notation	Value in 2014 ($ billions)		
		Corporate[1]	Non corporate[2]	Business[1+2]
Gross Value Added	P_tY_t	$8,641	$3,147	$11,788
Net Fixed Capital at Rep. Cost	$P_t^kK_t$	$14,857	$6,126	$20,983
Consumption of Fixed Capital	$\delta_tP_t^kK_t$	$1,286	$297	$1,583
Net Operating Surplus	$P_tY_t - W_tN_t - T_t^y - \delta_tP_t^kK_t$	$1,614	$1,697	$3,311
Gross Fixed Capital Formation	$P_t^kI_t$	$1,610	$354	$1,964
Net Fixed Capital Formation	$P_t^k(I_t - \delta_tK_t)$	$325	$56	$381

has become negative, thus creating the risk of a secular stagnation, an environment with low interest rates and output permanently below potential. Eggertsson and Mehrotra (2014) propose a model where secular stagnation can be triggered by a decrease in population growth, among other factors.

Gutiérrez and Philippon (2016), Alexander and Eberly (2016), and Lee et al. (2016) present recent firm and industry level evidence on investment and Q.

1 Empirical Evidence

1.1 Aggregate Evidence

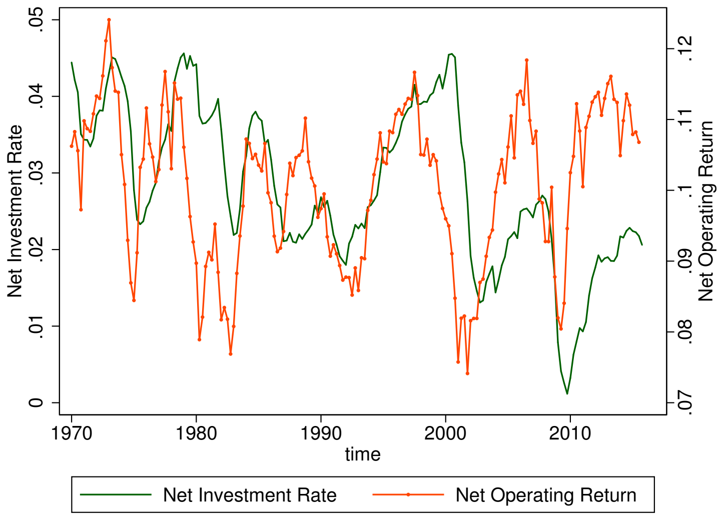
Table 1 summarizes some facts about the balance sheet and current account of the non financial business sector.

Figure 1 shows the net investment rate and the net operating return on capital of the non financial corporate, non financial non corporate and non financial business sector, defined as net operating surplus over the replacement cost of capital:

$$\text{Net Operating Return} = \frac{P_tY_t - \delta_tP_t^kK_t - W_tN_t - T_t^y}{P_t^kK_t}$$

The operating return fluctuates significantly but appears to be stationary. For corporates, the yearly average from 1971 to 2014 is 10%, with a standard deviation of only one percentage point. The minimum is 8.1% and the maximum 12.6%. In 2014, the operating return was 11.3%, close to the historical maximum. A striking feature is that the net operating margin was not severely affected by the Great Recession, and has been consistently near its highest value since 2010 for both Corporates and Non corporates.

Figure 1: Net Investment Rate and Net Operating Return



Note: Quarterly data for Non financial Businesses.

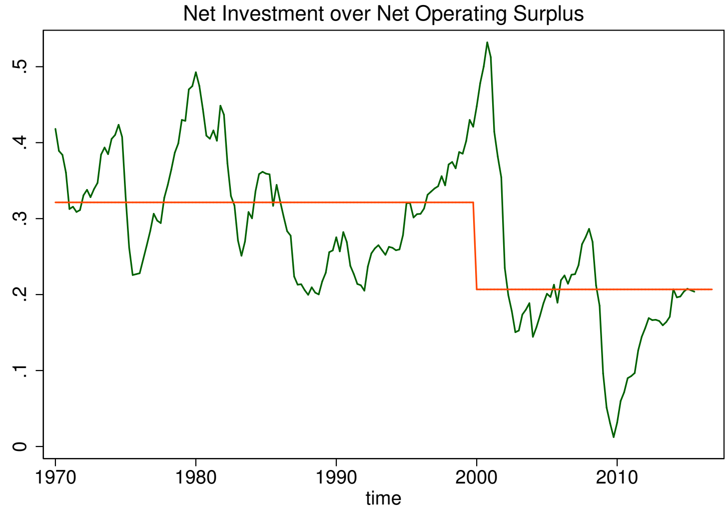
Firms are (very) profitable but they do not invest the same fraction of their operating returns as they used to. Figure 2 shows the ratio of net investment to net operating surplus for the non financial business sector:

$$^{NI}/_{OS} = \frac{P_t^k \left(I_t - \delta_t K_t\right)}{P_t Y_t - \delta_t P_t^k K_t - W_t N_t - T_t^y}$$

The average of the ratio between 1970 and 1999 is 32%. The average of the ratio from 2000 to 2015 is only 20.5%.[1] Current investment is low relative to operating margins. Similar patterns are observed when separating corporates and non corporates.

[1]Note that 2002 is used for illustration purposes only. It was chosen based on graphically, not based on a formal statistical analysis.

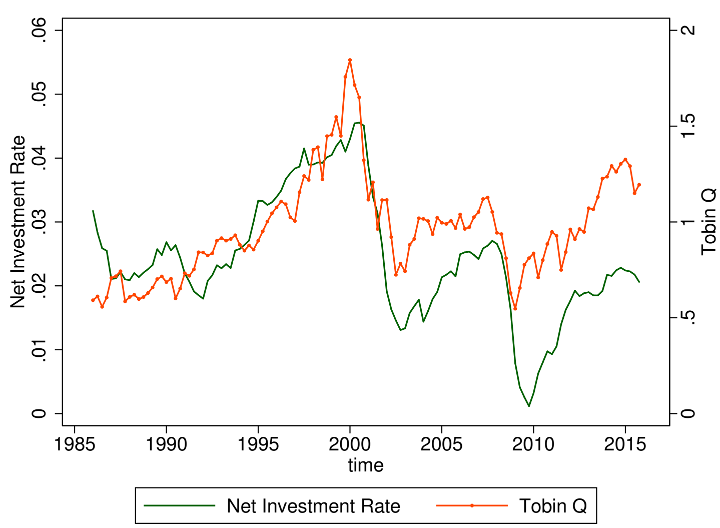
Figure 2: Net Investment Relative to Net Operating Surplus



Note: Quarterly data for Non financial Businesses.

Finally, investment is low relative to Q. The issue with Q is that it is not stationary and shows a significant change in its mean between the 1970s and 1980s. Figure 3 shows investment and Q starting in 1985. Q in 2015 is about the same as it was in 1998, yet the net investment rate is only barely more than 2% against almost 4% in 1998.

Figure 3: Investment and Q



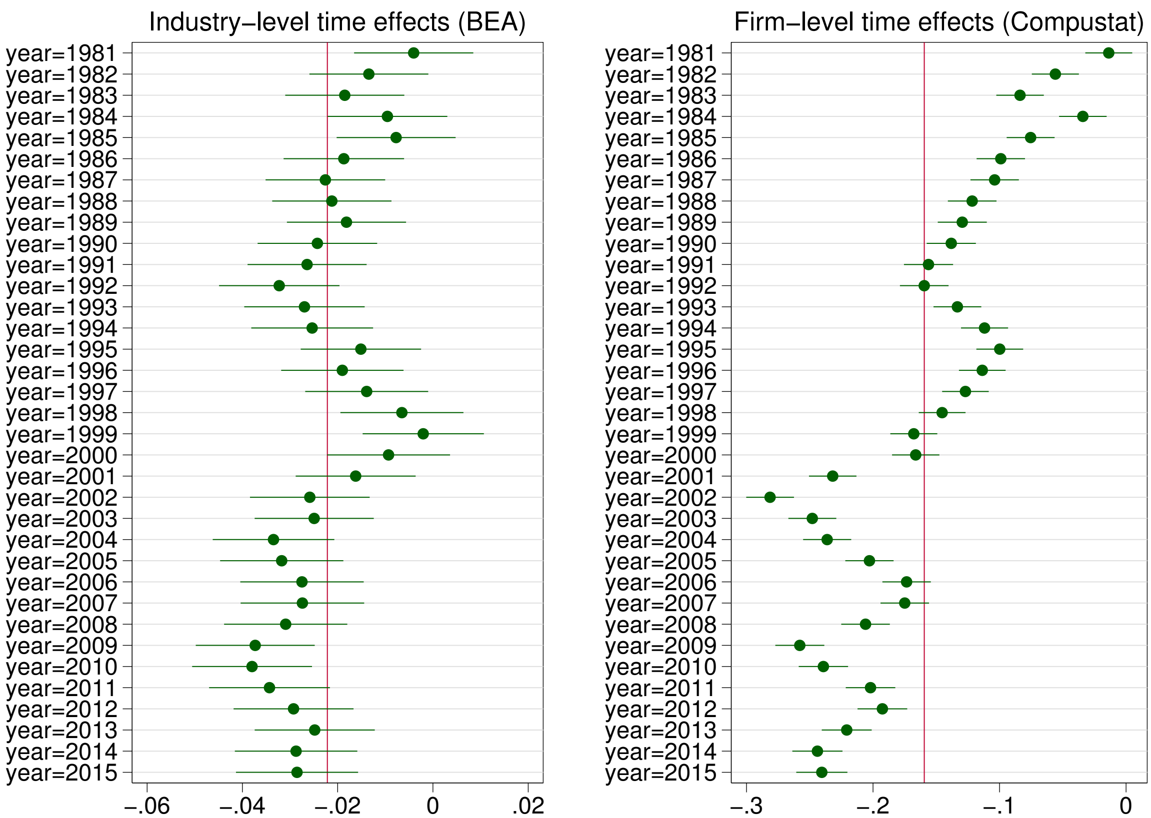
Note: Quarterly data. Q for Non Financial Corporate sector (data for Non Corporate sector not available)

1.2 Firm and Industry Evidence

We rely on the evidence presented in Gutiérrez and Philippon (2016). They show that investment is weak relative to measures of profitability and valuation – particularly Tobin's Q, and that this weakness starts in the early 2000's. The above regression focuses on aggregate investment. To study under-investment at a more granular level, Gutiérrez and Philippon (2016) estimate panel regressions of industry- and firm-level investment on Q; and study the time effects. Figure 4 shows their results: time effects for the industry regression are shown on the left and for the firm regression on he right. The vertical line highlights the average time effect across all years for each regression.[2] As shown, the time-effects are substantially lower for both Industry- and Firm-level regressions from 2000 onward. In the industry regression, time effects were above average in most years from 1980 to 2000 but have been consistently below-average since. In the firm regression, time effects were fairly high in the 1980s and slightly high in the 1990s. They approach the average as early as 1999 and turn substantially negative thereafter. These results are robust to including additional measures of fundamentals such as cash flow; considering only a subset of industries; and even splitting tangible and intangible assets. These results are consistent with those in Alexander and Eberly (2016), who consider firm-level gross investment, defined as the ratio of capital expenditures to assets.

[2] Note that the time effects need not be zero, on average, given the impact of adjustment costs in Q theory and the inclusion of a constant in the regression.

Figure 4: Time effects from Industry and Firm-level regressions



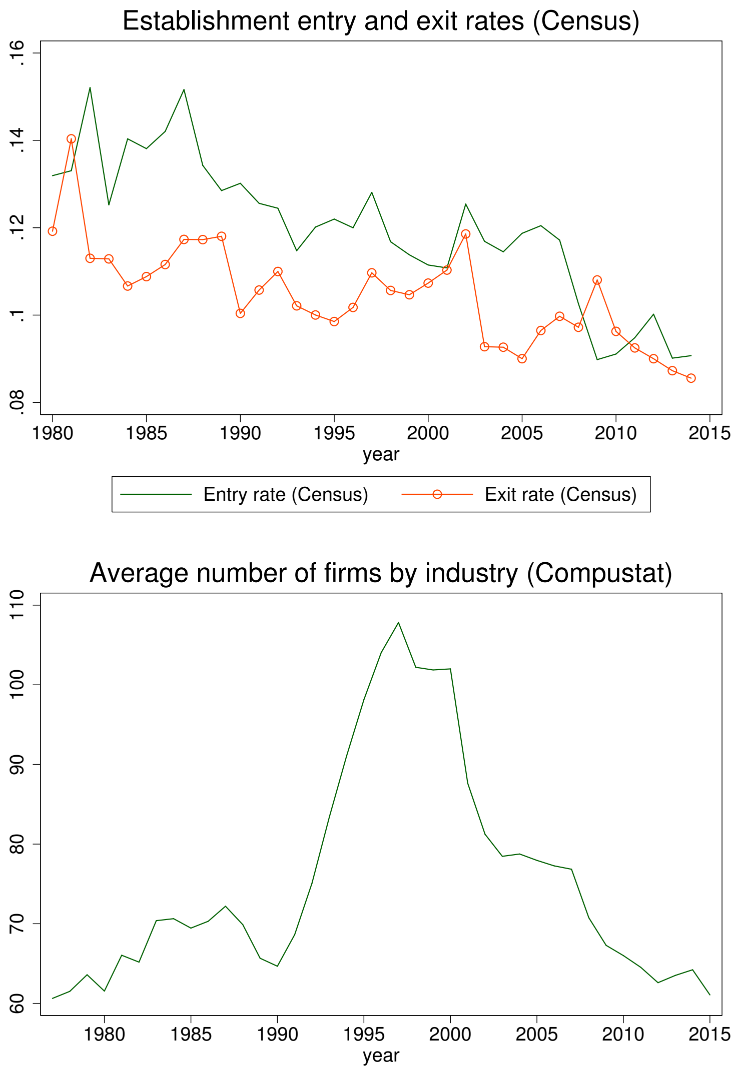
Note: Time fixed effects from industry- and firm-panel regressions of net investment on Q, with time as well as industry/firm fixed effects. Industry investment data from BEA; firm investment based on CAPX/Assets from Compustat.

The first important point to emphasize is that investment is not low because Q is low, but rather despite high Q. This simple point rules out a long list of potential explanations.

Gutiérrez and Philippon (2016) then use industry-level and firm-level data to test whether under-investment relative to Q is driven by (i) financial frictions, (ii) measurement error (due to the rise of intangibles, globalization, etc), (iii) decreased competition (due to technology or regulation), or (iv) tightened governance and/or increased short-termism. They find that proxies for competition and short-termism/governance explain the bulk of the investment gap, across industries and across firms. Industries with less entry and more concentration invest less, even after controlling for current market conditions. Within each industry-year, the investment gap is driven by firms that are owned by quasi-indexers and located in industries with less entry/more concentration. These firms spend a disproportionate amount of free cash flows buying back their shares.

Figure 5 shows two measures of firm entry: the establishment entry and exit rates as reported by the U.S. Census Bureau's Business Dynamics Statistics (BDS); and the average number of firms by industry in Compustat. In the early 1990s, we see a large increase in firms in Compustat, driven primarily by firms going public. Since then, both charts provide strong evidence of a decline in the number of firms. This downward trend in business dynamism has been highlighted by numerous papers (e.g., Decker et al. (2014)) but the trend has been particularly severe in recent years. In fact, Decker et al. (2015) argue that, whereas in the 1980s and 1990s declining dynamism was observed in selected sectors (notably retail), the decline was observed across all sectors in the 2000s, including the traditionally high-growth information technology sector.

Figure 5: Firm entry, exit and number of firms



Note: Annual data.

2 Benchmark Model

We use a standard DSGE model with capital accumulation, nominal rigidities, and time varying competition in the goods markets. For 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.

2.1 Capital Producer's Problem

Consider a firm that accumulates capital K to maximize its market value, taking as given the economy's pricing kernel Λ. Management chooses employment and investment to maximize firm value. Let V_t denote the cum-dividend value (i.e., at the beginning of time t, before dividends are paid):

$$V_t = \sum_{j=0}^{\infty} \Lambda_{t,t+j} Div_{t+j} \tag{1}$$

where Div_t are the distributions to the firm's owner. Capital accumulates as

$$K_{t+1} = (1 - \delta_t) K_t + I_t \tag{2}$$

Let R_k be the real rental rate, I_t gross investment, and P_t^k be the (real) price of investment goods. Investment is subject to convex adjustment costs à la Lucas and Prescott (1971) and we ignore taxes so

$$Div_t = R_{k,t} K_t - P_{k,t} I_t - \frac{\varphi_k}{2} P_{k,t} K_t \left(\frac{I_t}{K_t} - \delta_t \right)^2. \tag{3}$$

where the depreciation rate δ_t can be time varying (to match the data). The firm's problem is to maximize (1) subject to (2) and (3). We can write this as a dynamic programming problem

$$V_t (K_t) = \max_{I_t} Div_t + \mathbb{E}_t [\Lambda_{t+1} V_{t+1} (K_{t+1})]$$

Given our homogeneity assumptions, it is easy to see that the value function is homogeneous in K. We can then define

$$\mathcal{V}_t \equiv \frac{V_t}{K_t}$$

and net investment

$$x_t \equiv \frac{I_t}{K_t} - \delta = \frac{K_{t+1} - K_t}{K_t}$$

Then we have

$$\mathcal{V}_t = \max_x R_{k,t} - P_{k,t} (x_t + \delta_t) - \frac{\varphi_k}{2} P_{k,t} x^2 + (1 + x_t) \mathbb{E}_t [\Lambda_{t+1} \mathcal{V}_{t+1}]$$

The first order condition for the net investment rate is

$$P_{k,t}\left(1+\varphi_k x_t\right)=\mathbb{E}_t\left[\Lambda_{t+1}\mathcal{V}_{t+1}\right]$$

which we can write as a q-investment equation

$$x_t=\frac{1}{\varphi_k}\left(Q_t^k-1\right)$$

where

$$Q_t^k\equiv\frac{\mathbb{E}_t\left[\Lambda_{t+1}\mathcal{V}_{t+1}\right]}{P_t^k}=\frac{\mathbb{E}_t\left[\Lambda_{t+1}V_{t+1}\right]}{P_t^k K_{t+1}}$$

is Tobin's Q, i.e. the market value of the firm divided by the replacement cost of capital, all measured at the end of the period. We index it by k to distinguish it from the aggregate, measured Q which includes also the rents of the final producers. Tobin's Q satisfies the recursive equation

$$Q_t^k=\mathbb{E}_t\left[\frac{\Lambda_{t+1}}{P_t^k}\left(R_{k,t+1}+P_{k,t+1}\left(\left(1+x_{t+1}\right)Q_{t+1}^k-x_{t+1}-\delta_{t+1}-\frac{\varphi_k}{2}x_{t+1}^2\right)\right)\right]$$

which, given the FOC, can be written as

$$Q_t^k=\mathbb{E}_t\left[\frac{\Lambda_{t+1}}{P_t^k}\left(R_{k,t+1}+P_{t+1}^k\left(Q_{t+1}^k-\delta_{t+1}+\frac{1}{2\varphi_k}\left(Q_{t+1}^k-1\right)^2\right)\right)\right]$$

In the logic of the theory, Q_t is the discounted value of operating returns $R_{k,t+1}$, plus future Q net of depreciation, plus the option value of investing more when Q is high, and less when Q is low.

2.2 Households

We know introduce the familiar elements to close the model. We assume a balanced growth path with deterministic labor augmenting technological progress at rate $\bar{\mathsf{g}}$. Households maximize lifetime utility

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

subject to the budget constraint

$$S_t+P_tC_t\leq\tilde{R}_tS_{t-1}+W_tN_t,$$

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 trend growth term $(1+\bar{\mathsf{g}})^{(1-\gamma)t}$ is simply there to ensure balanced growth. The household's real pricing kernel is

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

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 Wage setting takes place as in the standard NK model. The wage reset at time t, W_t^*, solves

$$\mathbb{E}_t\sum_{k=0}^{\infty}(\beta\vartheta_w)^k N_{l,t+k}C_{t+k}^{-\gamma}\left(\frac{1-\epsilon_w}{P_{t+k}}+\epsilon_w\frac{\mathtt{MRS}_{t+k}}{W_t^*}\right)$$

where we define the marginal rate of substitution as

$$\mathtt{MRS}_{l,t+k}\equiv N_{l,t+k}^{\varphi}C_{t+k}^{\gamma}.$$

2.3 Price Setting

Firms have a Cobb-Douglass production function with stationary TFP shocks A_t and labor augmenting technology

$$Y_t=A_tK_t^{\alpha}\left((1+\bar{\mathfrak{g}})^tN_t\right)^{1-\alpha}-(1+\bar{\mathfrak{g}})^t\Phi$$

where Φ is a fixed cost of production, which ensures free entry despite monopoly rents. Firms take the wage and the rental rate as given when they hire capital and labor. The average cost of production is given by

$$\begin{aligned}&\min{}^{W}\!/_{P}N+R_kK\\&s.t.\\&Y=AK^{\alpha}N^{1-\alpha}\end{aligned}$$

The Cobb-Douglass function, like any CRS function, leads to a constant marginal cost. Taking into account the fixed cost, we get that the average cost is $\mathtt{MC}_tY_t+(1+\bar{\mathfrak{g}})^t\Phi$, where the real marginal cost is

$$\mathtt{MC}_t=\frac{1}{A_t}\left(\frac{R_{k,t}}{\alpha}\right)^{\alpha}\left(\frac{\frac{W_t}{(1+\bar{\mathfrak{g}})^tP_t}}{1-\alpha}\right)^{1-\alpha}$$

Cost minimization implies that all firms choose the same (optimal) capital labor ratio

$$\frac{\alpha}{1-\alpha}\frac{N_t}{K_t}=\frac{R_{k,t}}{W_t/P_t}$$

Firms set prices à la Calvo (with indexation on average inflation). The main departure from the standard model is that competition in the goods market varies over time. In the standard model, competition is characterized by the elasticity of substitution between goods, ϵ. In our baseline model, we simply assume that this elasticity varies over time. Then the price reset at time t, $P_{i,t}^*$, solves

$$\mathbb{E}_t\left[\sum_{k=0}^{\infty}\vartheta^k\Lambda_{t,t+k}Y_{i,t+k}\left(1-\varepsilon_{t+k}+\varepsilon_{t+k}\frac{P_{t+k}}{P^*_{i,t}}\mathtt{MC}_{t+k}\right)\right]=0$$

We consider different models of imperfect competition in extensions of the basic model.

3 Equilibrium

3.1 Detrended Model

The model defined above has a trend. We are going to write the equilibrium conditions of the detrended model. To avoid heavy notations, I do not change the symbols, since it is obvious which variables have trends

$$K_t := \frac{K_t}{(1+\bar{\mathtt{g}})^t}$$

and similarly for the other trending variables: $Y, I, \frac{W}{P}, \mathtt{MRS}$. The detrended model is therefore

$$\begin{aligned}
Y_t &= A_t K_t^{\alpha} N_t^{1-\alpha} - \Phi_t \\
Y_t &= C_t + P_{k,t} I_t + \frac{\varphi_k}{2} P_{k,t} K_t \left(\frac{I_t}{K_t} - \delta_t\right)^2 \\
(1+\bar{\mathtt{g}}) K_{t+1} &= (1-\delta_t) K_t + I_t \\
\frac{N_t}{1-\alpha}\frac{W_t}{P_t} &= R_{k,t}\frac{K_t}{\alpha} \\
\mathtt{MC}_t &= \frac{1}{A_t}\left(\frac{R_{k,t}}{\alpha}\right)^{\alpha}\left(\frac{W_t/P_t}{1-\alpha}\right)^{1-\alpha} \\
\mathtt{MRS}_t &= N_t^{\varphi} C_t^{\gamma} \\
\Lambda_{t+1} &= \beta (1+\bar{\mathtt{g}})^{-\gamma}\left(\frac{C_t}{C_{t+1}}\right)^{\gamma} \\
\frac{I_t}{K_t} - \delta_t &= \frac{1}{\varphi_k}(Q_t - 1) \\
Q_t^k &= \mathbb{E}_t\left[\frac{\Lambda_{t+1}}{P_{k,t}}\left(R_{k,t+1} + P_{k,t+1}\left(Q_{t+1}^k - \delta_{t+1} + \frac{1}{2\varphi_k}\left(Q_{t+1}^k - 1\right)^2\right)\right)\right]
\end{aligned}$$

Finally, the measured value of Q includes the rents of the final producers

$$Q = Q_t^k + \frac{\mathbb{E}_t\left[\Lambda_{t+1}V_{t+1}^{\epsilon}\right]}{P_t^k K_{t+1}}$$

where the value of the final producers is

$$V_t^{\epsilon} = P_t Y_t (1 - \mathtt{MC}_t) - \Phi_t + \mathbb{E}_t\left[\Lambda_{t+1}V_{t+1}^{\epsilon}\right]$$

This theoretical Q is the one that we can compare to Tobin's Q in the data.

Finally, we need to specify a policy rule for the central bank, taking into account the zero lower bound on nominal interest rates. We assume that monetary policy follows a Taylor rule for the nominal interest rate

$$i_t^* = -\log(\beta) + \phi_p \pi_t^p + \phi_w \pi_t^w + \phi_y (n - \bar{n})$$

but the actual short rate is constrained by the zero lower bound

$$i_t = \max(0; i_t^*)$$

We discuss the issue of forward guidance in the estimation section.

3.2 Shocks

We introduce the following shocks to the model (in logs):

- Productivity shock:

$$a_t = \rho_a a_{t-1} + \epsilon_{a,t}$$

- Discount rate shock to the pricing kernel

$$\begin{aligned} \lambda_{t+1} &= \log\beta - \gamma(c_{t+1} - c_t) + \zeta_t^d \\ \zeta_t^d &= \rho_d \zeta_{t-1}^d + \epsilon_t^d \end{aligned}$$

- A shock to the valuation of corporate assets

$$\begin{aligned} q_t^k &= \mathbb{E}_t\left[\lambda_{t+1} + \log\left(r_{t+1}^k + q_{t+1} + 1 - \delta + \frac{1}{2\gamma} q_{t+1}^2\right)\right] + \zeta_t^q \\ q_t^\epsilon &= \mathbb{E}_t\left[\lambda_{t+1} + v_{t+1}^\epsilon - k_{t+1}\right] + \zeta_t^q \\ \zeta_t^q &= \rho_d \zeta_{t-1}^q + \epsilon_t^q \end{aligned}$$

The discount rate shock will help us account for the sharp drop in risk free rates during the Great Recession, as in the standard NK model. The valuation shock is a risk premium shock that applies to corporate (risky) assets. It is important to account for time varying-risk aversion and expected returns.

The novel part of our model is that competition varies over time. In our benchmark model we capture this idea with a time varying elasticity ε_t. We assume that it follows a random walk, so at any point in time, the agents in our model anticipate that competition will (on average) remain at its current level.

- Time-varying elasticity of substitution between goods

$$\varepsilon_t = \varepsilon_{t-1} + \epsilon_t^\varepsilon$$

A crucial point of our analysis is that ε is not a free series of shocks. We *measure* it in the data, as explained in the next section. We solve for the path of the economy using the solution method and approach of Jones (2016), as explained in the Appendix.

4 Industry Model and Calibration

We want to use the evidence in Gutiérrez and Philippon (2016) to calibrate and estimate our model. Their evidence is cross-sectional, based on heterogeneity across industries (and firms), so we need to extend the model to obtain a realistic mapping.

4.1 Theory

In the standard model C is an index of goods

$$C_t \equiv \left(\int_0^j C_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{4}$$

where ϵ is the elasticity of substitution between goods. Utility maximization implies that the relative demand of any two goods satisfies $\frac{C_{i,t}}{C_{j,t}} = \left(\frac{P_{i,t}}{P_{j,t}}\right)^{-\epsilon}$. This then implies the existence of a price index, defined by

$$P_t \equiv \left(\int_0^1 P_{j,t}^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}, \tag{5}$$

such that consumption expenditures are $P_t C_t = \int_0^1 P_{j,t} C_{j,t} dj$, and the demand curves are simply $C_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon} C_t$. Now we want to think of $j \in [0,1]$ as industries, and each industry is populated by firms $i \in [0,1]$ (so technically a firm is point $(i,j) \in [0,1]^2$):

$$C_{j,t} = \left(\int_0^j C_{i,j,t}^{\frac{\epsilon_j - 1}{\epsilon_j}} dj \right)^{\frac{\epsilon_j}{\epsilon_j - 1}}$$

Firm i in industry j takes $Y_{j,t} = C_{j,t}$ as given and sets its price to maximize

$$\mathbb{E}_t \left[\sum_{k=0}^{\infty} \vartheta^k \Lambda_{t,t+k}^{\$} \left(P_{i,j,t}^* Y_{i,j,t+k} - W_{t+k} N_{i,j,t+k} - R_{t+k}^k K_{i,j,t+k} \right) \right]$$

subject to the demand curve $Y_{i,j,t+k} = \left(\frac{P_{i,t}^*}{P_{t+k}}\right)^{-\epsilon} Y_{j,t+k}$. Since all the firms face the same factor prices, they will have the same marginal cost

$$\mathtt{MC}_t = \frac{1}{A_t} \left(\frac{R_{k,t}}{\alpha} \right)^{\alpha} \left(\frac{\frac{W_t}{(1+\bar{\mathrm{g}})^t P_t}}{1-\alpha} \right)^{1-\alpha}$$

and they will choose the same (optimal) capital labor ratio

$$\frac{\alpha}{1-\alpha}\frac{N_t}{K_t} = \frac{R_{k,t}}{W_t/P_t}$$

Firms set prices à la Calvo with indexation on average inflation, so the price reset at time t, $P^*_{i,t}$, solves

$$\mathbb{E}_t\left[\sum_{k=0}^{\infty}\vartheta^k\Lambda_{t,t+k}Y_{i,j,t+k}\left(1-\epsilon_j+\epsilon_j\frac{P_{j,t+k}}{P^*_{i,j,t}}\frac{P_{t+k}}{P_{j,t+k}}\mathtt{MC}_{t+k}\right)\right]=0$$

In steady state, we have $\frac{P_{j,t}}{P^*_{i,j,t}} = 1$ and

$$\frac{P_j}{\bar{P}} = \mu_j\mathtt{MC}$$

where$\mu_j \equiv \frac{\epsilon_j}{\epsilon_j-1}$. Therefore since$\bar{P} \equiv \left(\int_0^1 P_j^{1-\epsilon}dj\right)^{\frac{1}{1-\epsilon}}$ we have

$$\mathtt{MC} \equiv \left(\int_0^1 (\mu_j)^{1-\epsilon}\,dj\right)^{\frac{-1}{1-\epsilon}}$$

and

$$C_j = (\mu_j\mathtt{MC})^{-\epsilon}\,C$$

Since $C_j = Y_j = AK_j^{\alpha}N_j^{1-\alpha}$ and all the firms and industries use the same factor intensities we can write

$$Y_j = AK_j\left(\frac{N}{K}\right)^{1-\alpha}$$

and we get in the cross-section

$$\log K_j = cte - \epsilon\log\mu_j$$

4.2 Data

Using the data of Gutiérrez and Philippon (2016), we measure the concentration ratio, $\chi_{j,t}$ as the share of sales by the top 8 firms in the industry (concentration ratio). In a panel regression across industries, including time fixed-effects and industry fixed-effects, we find

$$\log K_{j,t} = -1.3\chi_{j,t} + ...$$

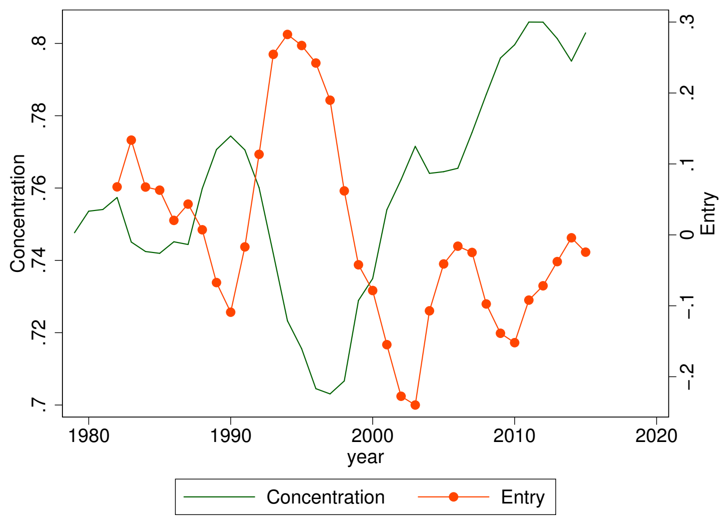
If the relative concentration ratio of an industry increases by 1%, its relative capital stock decreases by 1.3%. This result holds for various types of investment goods, for various controls, and also when instrumenting for the degree of competition.

To match the model and the data, we need to specify the elasticity of substitution between industries, ϵ. Following the trade literature, we take as a benchmark a value of 1 for the elasticity of substitution between broad classes of goods. Hence we have $\log\mu_{j,t} \approx 1.3\chi_{j,t}$. In the aggregate, we can calibrate the evolution of competition as

$$\log \bar{\mu}_t = \log \frac{\epsilon_t}{\epsilon_t - 1} \approx 1.3 \bar{\chi}_t$$

Figure 6 shows the series for the average concentration across industries in our sample. Concentration decreased in the 1990s, and increased in the 2000s. We also include a measure of entry, the 3-year log-change in the number of firms.

Figure 6: Entry and Concentration



Note: Annual data for Non financial Businesses (Corporate and Non corporate).

5 Simulation Result

5.1 Estimation of the Model

The parameters of the model are calibrated in the standard way. We perform a simulation over the period 1986:1 to 2015:1. We use as data consumption, the net investment rate, the nominal interest rate, and the expected duration of the ZLB obtained from Federal Funds futures and Morgan Stanley. The persistence and size of the shock processes are estimated using maximum likelihood with data from 1986Q1 to 2015Q1. The remaining parameters are calibrated to standard values. Our data includes:

$$Data = \left(\log \left(C_t \right); \frac{I_t}{K_t} - \delta_t; \log \left(1 + r_t^{3m} \right); T_t \right)_{t=[1986:1;2015:1]}$$

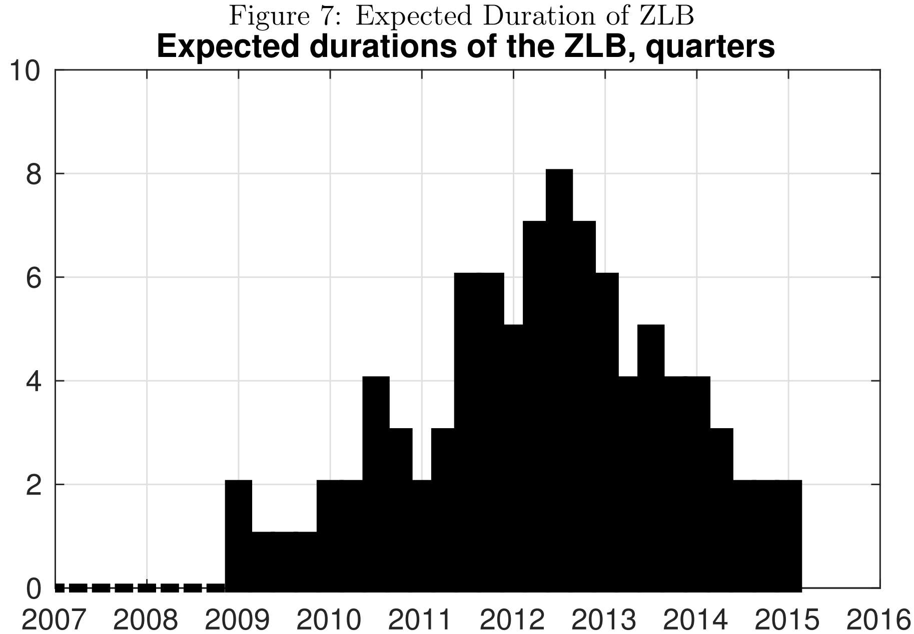
where C_t is real consumption per capita, r_t^{3m} is the 3-month Treasury Bill rate, T_t is the expected duration of the ZLB, and the other variables are as defined earlier. We use the Kalman filter to recover the three unobserved shocks introduced above:

$$Shocks = \left(a_t, \zeta_t^d, \zeta_t^q\right)$$

A critical issue is the presence of the ZLB. It implies that the short rate becomes uninformative when it reaches 0. For any time t where $i_t = 0$, what matters for agents in the model is the expected duration of the ZLB episode, which we call T_t. So what enters the Kalman filter in period t is either i or T, whichever is strictly positive.

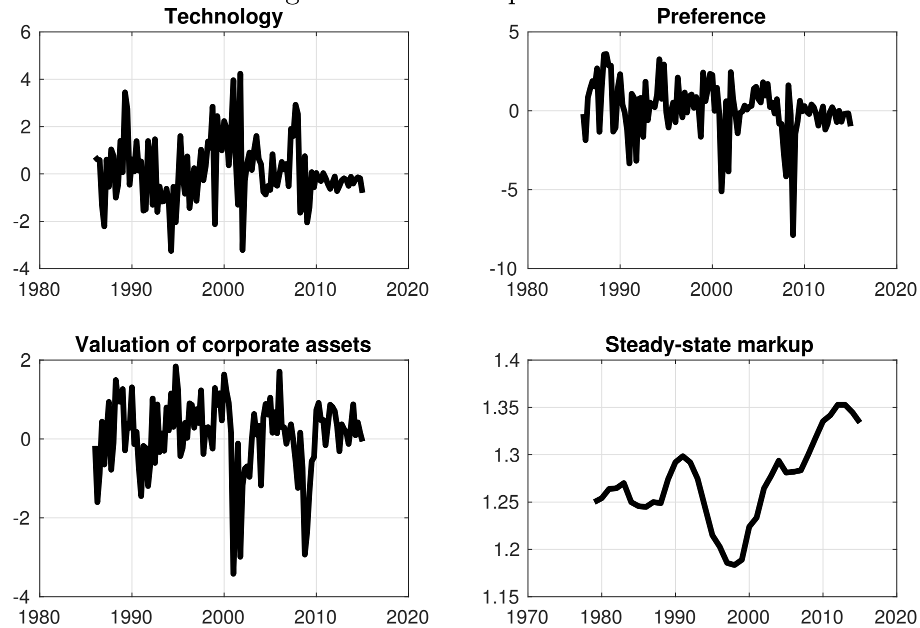
There are several ways to construct T_t. We use a measure constructed by Morgan Stanley from the Fed Funds Futures contracts. Figure 7 presents our series for T_t, based on i^*. In 2013, agents in the model anticipate the ZLB to last about two years. By 2015, the agents anticipate a lift off in the near future. In the next step, we will estimate the model using long rates, following Swanson and Williams (2014).

Figure 7: Expected Duration of ZLB



Once we have chosen a particular series for T_t, we can recover the three shocks following the methodology described in Jones (2016). 8 presents the shocks. There is a large innovation to the discount rate around the time of the Great Recession.

Figure 8: Model-Implied Shocks



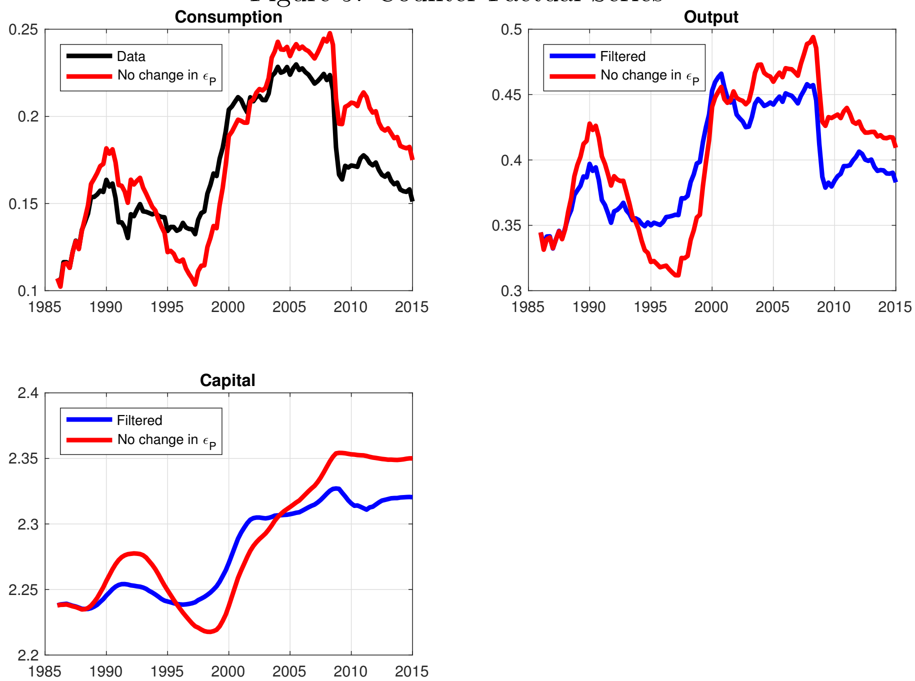
Notes: Quarterly data, shocks in units of standard deviation.

Our main interest is in the time varying markup. It increases substantially from a markup of 20% to one of 35% from 2000 to 2011.

5.2 Counter-Factual

We now present our main results. The observed, filtered, and counterfactual levels of the real variables are presented in Figure 9. Absent the decline in the elasticity of substitution, the levels of log output, log consumption, and log capital would have been significantly higher from 2000 onwards.

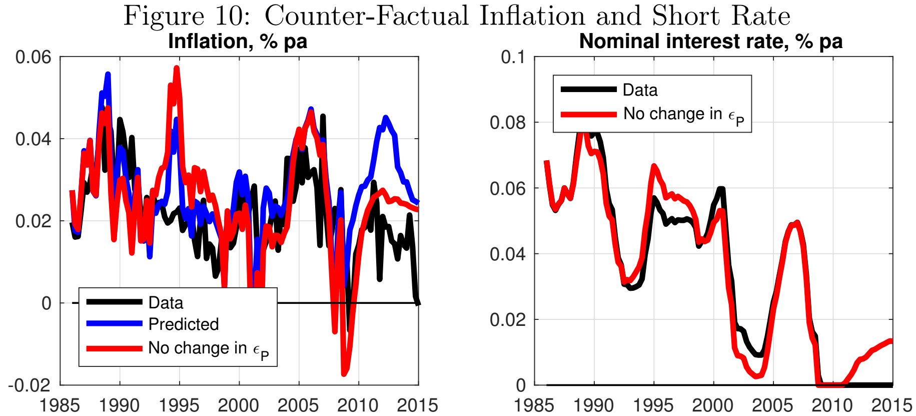
Figure 9: Counter-Factual Series



Notes: Quarterly data, shocks in units of standard deviation.

The counterfactual paths for inflation and the nominal interest rate are presented in Figure 10. The observed inflation rate (CPI inflation) is plotted alongside the prediction of inflation from the full model, and the counterfactual path of inflation when the shocks to the elasticity of substitution are turned off. Absent the changes in the elasticity, the nominal interest rate would increased to just less than 2 per cent per annum in 2015. This is primarily a result of responding to the higher counterfactual level of output when goods markets are more competitive without the trend increase in the steady-state markup. That is, the increase in aggregate demand would have had a large impact on the equilibrium rate.

Figure 10: Counter-Factual Inflation and Short Rate



Notes: Quarterly data, shocks in units of standard deviation.

6 Conclusions

We have studied a simple New Keynesian model in which shocks occasionally trigger the zero lower bound on interest rates. We find that the slow recovery of the U.S. economy is not driven by weak consumption and depressed asset prices as the standard liquidity trap theory would predict. Instead, the slow recovery is explained by an apparent lack of willingness of businesses to invest despite favorable economics conditions, i.e. despite historically high profit margin, high asset prices and low funding costs. This investment gap, in turn, is explained by a decreased in competition in the goods market.

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7 Appendix

7.1 Equilibrium Conditions

We have 12 real unknowns $\{Y_t, N_t, C_t, I_t, K_{t+1}, {}^{W_t}/_{P_t}, R_{k,t}, \mathtt{MC}_t, \mathtt{MRS}_t, \Lambda_{t+1}, R_t, Q_t\}$ and 10 equations:

$$
\begin{aligned}
Y_t &= A_t K_t^{\alpha} \left((1+\bar{\mathtt{g}})^t N_t \right)^{1-\alpha} - (1+\bar{\mathtt{g}})^t \Phi \\
Y_t &= C_t + P_{k,t} I_t + \frac{\varphi_k}{2} P_{k,t} K_t \left(\frac{I_t}{K_t} - \delta_t \right)^2 \\
K_{t+1} &= (1-\delta_t) K_t + I_t \\
\frac{N_t}{K_t} &= \frac{1-\alpha}{\alpha} \frac{R_{k,t}}{{}^{W_t}/_{P_t}} \\
\mathtt{MC}_t &= \frac{1}{A_t} \left(\frac{R_{k,t}}{\alpha} \right)^{\alpha} \left(\frac{\frac{W_t}{(1+\bar{\mathtt{g}})^t P_t}}{1-\alpha} \right)^{1-\alpha} \\
\mathtt{MRS}_t &= (1+\bar{\mathtt{g}})^{(1-\gamma)t} N_t^{\varphi} C_t^{\gamma} \\
\Lambda_{t+1} &= \beta \left(\frac{C_t}{C_{t+1}} \right)^{\gamma} \\
\frac{I_t}{K_t} - \delta_t &= \frac{1}{\varphi_k} (Q_t - 1) \\
1 &= \mathbb{E}_t \left[\Lambda_{t+1} \frac{P_t}{P_{t+1}} R_t \right] \\
Q_t^k &= \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{P_t^k} \left(R_{k,t+1} + P_{t+1}^k \left(Q_{t+1}^k - \delta_{t+1} + \frac{1}{2\varphi_k} \left(Q_{t+1}^k - 1 \right)^2 \right) \right) \right]
\end{aligned}
$$

The extra two equations to close the model depend on the frictions that we consider.

- With competitive goods markets and flexible prices, the price of output must equal the marginal cost: $\mathtt{MC}_t = 1$;
- Without frictions in the labor market, the real wage must equal the marginal rate of substitution: $\mathtt{MRS}_t = {}^{W_t}/_{P_t}$;
- NK models introduce markups and frictions in both markets and use the equilibrium conditions presented above.

7.2 Steady State

To compute the steady state, we normalize $A = 1$. As usual in this class of model with a representative saver, the discount rate is pinned down by the rate of time preference: $\Lambda = \beta (1+\bar{\mathtt{g}})^{-\gamma}$. Constant capital requires $\frac{I}{K} = \delta + \bar{\mathtt{g}}$ and thus

$$Q^k = 1 + \bar{\mathtt{g}} \varphi_k.$$

Since Q is constant in steady state, we have $Q^k = \Lambda\left(\frac{R_k}{P^k} + Q^k - \delta + \frac{\bar{\mathtt{g}}^2\varphi_k}{2}\right)$.[3] This pins down the required rental rate R_k as a function of discounting and the technology to produce capital goods (P_k, φ_k):

$$\frac{R_k}{P_k} = \delta + \left(\frac{1}{\Lambda} - 1\right) Q^k - \frac{\bar{\mathtt{g}}^2\varphi_k}{2}$$

Monopoly pricing implies a markup of price over marginal cost:

$$\mathtt{MC} = \frac{\epsilon_p - 1}{\epsilon_p}$$

This pins down the real wage:

$$\frac{W}{P} = (1-\alpha)\left(\frac{\epsilon_p - 1}{\epsilon_p}\right)^{\frac{1}{1-\alpha}}\left(\frac{R_k}{\alpha}\right)^{-\frac{\alpha}{1-\alpha}}$$

Labor demand then pins down the ratio of labor to capital

$$\frac{N}{K} = \left(\frac{\epsilon_p}{\epsilon_p - 1}\frac{R_k}{\alpha}\right)^{\frac{1}{1-\alpha}}$$

which is the standard MPK condition adjusted for the markup. From the capital labor ratio we get the capital output ratio:

$$\frac{Y + \Phi}{K} = \left(\frac{N}{K}\right)^{1-\alpha}$$

Now we need to think about the fixed cost and the valuation of firms. The valuation of rents is

$$V_t^\epsilon = P_t Y_t \left(1 - \mathtt{MC}_t\right) - \Phi_t - + \mathbb{E}_t\left[\Lambda_{t+1} V_{t+1}^\epsilon\right]$$

so in steady state with $P = 1$, we have

$$V^\epsilon = \frac{Y_t\left(1 - \mathtt{MC}_t\right) - \Phi}{1 - \Lambda}$$

We think of a model where corporate value must cover fixed costs with some excess premium, so

$$\Phi = \frac{\phi}{\epsilon_p} Y$$

so

$$V^\epsilon = \frac{(1-\phi)\, Y_t \left(1 - \mathtt{MC}_t\right)}{1 - \Lambda}$$

and

$$\frac{Y}{K}\left(1 + \frac{\phi}{\epsilon_p}\right) = \left(\frac{N}{K}\right)^{1-\alpha}$$

[3]The last term $\frac{\mathtt{g}^2\varphi_k}{2}$ is small since $\mathtt{g}$ is a small number. For instance, with annual data, we would get $\mathtt{g} = 2\%$ and with adjustment costs of 10 (an upper bound), this term is only 2%.

Then $Y = C + I + \frac{\varphi_k}{2} K \left(\frac{I}{K} - \delta\right)^2$ implies

$$\left(\frac{N}{K}\right)^{1-\alpha} - \frac{\Phi}{K} = \frac{C}{K} + \delta + \bar{\mathrm{g}} + \frac{\varphi_k}{2}\bar{\mathrm{g}}^2 \Longrightarrow \frac{C}{K} = \frac{1}{1+\frac{\phi}{\epsilon_p}}\left(\frac{N}{K}\right)^{1-\alpha} - \delta - \bar{\mathrm{g}} - \frac{\varphi_k}{2}\bar{\mathrm{g}}^2$$

which also means $\alpha\frac{C}{K} = \frac{1-\beta}{\beta} + (1-\alpha)\,\delta - \alpha\bar{\mathrm{g}} - \alpha\frac{\varphi_k}{2}\bar{\mathrm{g}}^2$. And the labor supply condition, with the wage markup, pins down K

$$K = \left(\frac{\epsilon_w - 1}{\epsilon_w}\frac{W}{P}\left(\frac{C}{K}\right)^{-\gamma}\left(\frac{N}{K}\right)^{-\varphi}\right)^{\frac{1}{\varphi+\gamma}}$$

Which we can use to get steady state employment

$$N = \frac{N}{K} \times K$$

7.3 Methodology

The model is approximated subject to an unanticipated trend in the elasticity of substitution between intermediate goods. The nominal interest rate is also subject to the zero lower bound. This section describes the methodology used.

First, consider the time-invariant approximation of a rational-expectations model of the form $x_t = \Psi(x_{t-1}, \mathbb{E}_t x_{t+1}, \varepsilon_t)$ where x_t is the vector of model variables (state and jump), and ε_t is a vector of exogenous unanticipated shocks whose stochastic properties are known. The well-known rational expectations approximation of the model, linearized around its steady state, is written as:

$$\mathbf{A}x_t = \mathbf{C} + \mathbf{B}x_{t-1} + \mathbf{D}\mathbb{E}x_{t+1} + \mathbf{F}\epsilon_t \tag{6}$$

where $\mathbf{A}$, $\mathbf{B}$, $\mathbf{C}$, $\mathbf{D}$, and $\mathbf{F}$ are matrices that encode the structural equations of the model. A solution is:

$$x_t = \mathbf{J} + \mathbf{Q}x_{t-1} + \mathbf{G}\epsilon_t$$

where $\mathbf{J}$, $\mathbf{Q}$, and $\mathbf{G}$ are conformable matrices which are functions of $\mathbf{A}$, $\mathbf{B}$, $\mathbf{C}$, $\mathbf{D}$, and $\mathbf{F}$.

When agents in the model have time-varying beliefs about the evolution of the model's structural parameters, then: $x_t = \Psi_t(x_{t-1}, \mathbb{E}_t x_{t+1}, \varepsilon_t)$. Denote the corresponding structural matrices for the model linearized at each point in time around the steady state corresponding to the time t structural parameters by $\mathbf{A}_t$, $\mathbf{B}_t$, $\mathbf{C}_t$, $\mathbf{D}_t$, and $\mathbf{F}_t$. A solution to the problem with time-varying structural matrices exists if agents in the model expect the structural matrices to be fixed in the future at values which are consistent with a time-invariant equilibrium Kulish and Pagan (2016).[4] In this case, the solution has a time-varying VAR representation:

$$x_t = \mathbf{J}_t + \mathbf{Q}_t x_{t-1} + \mathbf{G}_t\epsilon_t \tag{7}$$

where $\mathbf{J}_t$, $\mathbf{Q}_t$, and $\mathbf{G}_t$ are conformable matrices which are functions of the evolution of beliefs about

[4] Also see Jones (2015) and Guerieri and Iacoviello (2015), who apply this procedure to approximating models with occasionally binding constraints quickly and efficiently.

the time-varying structural matrices $\mathbf{A}_t$, $\mathbf{B}_t$, $\mathbf{C}_t$, $\mathbf{D}_t$, and $\mathbf{F}_t$, satisfying the recursion:

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

where the final structures $\mathbf{Q}_T$ and $\mathbf{J}_T$ are known and computed from the time invariant structure above under the terminal period's structural parameters. The solution shows that the law of motion for the model's state variables at a time period t depends on the full anticipated path of the structural matrices.

Once the model is in the time-varying VAR representation, then it is straightforward to express the model in its state-space representation and to use the Kalman filter.

7.4 The zero lower bound

The occasionally binding zero lower bound constraint is implemented using solution (6) with a regime-switching algorithm, where the two regimes are the zero lower bound regime and a Taylor-rule policy regime (for full details, see Jones, 2015). Agents have rational expectations over which of the two regimes will apply at each point in time. The algorithm iterates on the forecast time periods that the zero lower bound regime applies. To obtain the time-varying representation (7) that reflects an expected duration of the zero lower bound at each point in time, the method iterates backwards through the model's structural equations starting from the system (6) that arises at the expected exit from the zero lower bound regime.

The zero lower bound duration that agents expect is not constrained to be the same duration as that implied by structural shocks. In this case, the central bank has actively extended the zero lower bound duration through a policy of calendar-based forward guidance. In the estimation, these expected zero lower bound durations are set to those implied by Federal Funds futures data. This ensures forward guidance policy over the post-2009 period is taken into account.