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MARKETS STRUCTURE AND SECULAR STAGNATION

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Abstract

I investigate the relation between market structure and Secular Stagnation, from a theoretical and an empirical standpoint. By means of a 3-periods OLG model, I show that an increase in the share of profits triggers a decline in the natural interest rate and employment. I extend the model to 16 five-year periods and I introduce exogenous job destruction and a matching function. Under labor market frictions, the steady state features permanently lower equilibrium interest rate and lower employment, and the increase in market power has stronger effects, hence suggesting that neglecting these frictions may likely bias the evaluation of the phenomena behind Secular Stagnation. In particular, firms post less vacancies, employment falls, wage bargaining implies permanently lower wages and, the number of discouraged workers increases. The model rationalizes the contemporaneous decline of the employment rate, the input shares, and the equilibrium interest rate. The estimation of a structural VAR with long-run restrictions confirms the above results.

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Keywords: market structure, labor market, natural interest rate, secular stagnation, hysteresis

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Introduction

In outlining the theory of Secular Stagnation, Hansen (1939) focused on the role played by the process of capital formation in achieving full employment and on the key effect of population growth. By Secular Stagnation he meant "*sick recoveries which die in their infancy and depressions which feed on themselves and leave a hard and seemingly immovable core of unemployment, which leave large unemployment behind.*". He noticed that many factors may affect the achievement of full employment, slowing down the process of capital formation and thus progress. The development of monopolistic competition is among these factors and "the workability of free enterprise"is one of the main policy challenges. Despite this significant role, little attention has been paid on the relation between market structure and Secular Stagnation. Moreover, little effort has been put in place to recognize the connection between the main mechanisms behind the Secular Stagnation literature developed in the late 30s and the ones behind its late sister, the Hysteresis theory. The latter was put forward in the late 80s by Blanchard and Summers (1986) and it contemplates "*the substantial persistence of unemployment and the protracted effects of shocks on unemployment*". Blanchard and Summers (1986) mainly referred to the high unemployment afflicting the European economies in the 80s, and they focused on the role played by the labor market structure and frictions.

In this research, I intend to fill these gaps by providing a theoretical analysis on the link between the market structure and Secular Stagnation, taking into account how labor market frictions affect the results. In addition, I verify the testable implication through an empirical VAR model, and I show that an increase in the profits share does trigger a persistent decline both in employment and in the natural interest rate.

The research question is extremely relevant, for two key features of the last decades for the US economy, and not only, have been indeed the decrease in the interest rate and deep changes in the market structure. Figure 5a shows that the interest rate has experienced a downtrending path since the 90s, though the latter has been masked by the bubbly episodes, the IT and the housing bubbles. Alternative interest rate measures show a similar pattern. Moreover, the US are not an isolated case and, as most recently discussed by Fisher (2016), interest rates have dropped, even below zero, in an increasing number of countries.

Significant changes have occurred also in the market structure. There has been a decrease in business dynamism, and, as Figure 5b shows, the number of listed companies has declined[1]. Moreover, there has been an increase in market power, as captured by the increase in M&A activity[2] in Figure 5c; the increase in profits as a share of GDP, Figure 5d, and; the rise in concentration, as the share of sales of top 50 companies[3], in almost all the industries, Table 5. Looking at aggregate firms data, there has been a decrease in the labor share, in capital expenditures and gross investment. Figures 6a, 6b and 6c show, respectively, the series for labor share, capital expenditures and gross investment scaled by total assets for nonfinancial business. The three series are highly persistent, and trend downward during the sample, though investment in particular shows a clear business-cycle pattern, growing in expansion and falling during recession[4]. Finally, concerning the labor market, Figures 6d, 6e and 6f show the three key stylized facts: while the unemployment rate is extremely low, back to where it was before the Crisis, the employment rate has fallen below the level observed at the beginning of the 90s and the share of people in working-age out of the labor force[5] has increased.

Motivated by these stylized facts, I propose an OLG model with market power to interpret the empirical evidence. In the baseline model, I assume that there is monopoly power in the intermediate goods sector, and firms earn a constant, exogenous share of profits. I show that an increase in the latter puts a downward pressure on the equilibrium interest rate. The key economic channel for the market power to affect the equilibrium interest rate is the market for inputs. Firstly, an increase in market power reduces output, and therefore demand for labor, thus putting downward pressure on wages. Secondly, I

[1] The US "listing gap" has been analyzed recently by Doidge et al. (2015). They show that the high delist rate is explained by an unusually high rate of acquisitions of publicly-listed firms.

[2] Blonigen and Pierce (2016) provide evidence of increased markups after M&As.

[3] I consider the concentration index released by the Census Bureau, based on the share of sales of the top 50 companies. Data are available until 2012, though a report by CEA (2016) confirms the trend for the most recent years.

[4] Gruber and Kamin (2015) show that the fall of corporate investment goes beyond their model's predictions and it is inconsistent with the view of a cautious investment strategy by firms. Gutiérrez and Philippon (2016) attribute the fall in investment to decreased competition.

[5] Not in labor force as a % Working Age Population: Aged 15-64: All Persons for the United States.

assume that the only outside asset for saving, available to households, is capital, which is used as a production input within the same rental period and pays a rental rate. The increase in market power, which reduces output and demand for capital, pushes down the return on capital, hence putting a downward pressure on the equilibrium interest rate. Eventually, the zero lower bound on the interest rate may break the adjustment mechanism and "an equilibrium where the equilibrium real interest rate consistent with full employment is permanently negative" may arise, that is Secular Stagnation following the interpretation by Eggertsson et al. (2017).

I extend the model to allow for a multi-period OLG framework and labor market frictions. The key motivation for this extension is to reconcile the view expressed by Blanchard and Summers (1986) within Secular Stagnation, and to assess whether labor market frictions do matter, i.e.: 1) whether labor market frictions impact the natural interest rate and 2) whether they amplify the effects of the increase of monopoly power. Labor market frictions are à la Diamond, Mortensen and Pissarides, and the wage bargaining process is carried on by workers, the "*insiders* "in Blanchard and Summers (1986). I abstract from shocks to demographics and productivity, and from aggregate uncertainty, and I assume perfect risk sharing across individuals of a given generation. I show that, for a given calibration, the economy with labor market frictions features permanently lower equilibrium interest rate and employment rate. Moreover, I show that labor market frictions exacerbate the negative effects of an increase in the profits share. The mechanism is an amplified version of the one described for the baseline model. An increase in monopoly power lowers firms demand for input and their costs, and induce firms to demand less capital and to post less vacancies. The consequence is lower employment rate, lower bargained wages and lower probability of finding a job, while the number of discouraged workers (early-retirees) increases.

In the last section of the paper, I verify the testable implication arising from the theoretical model and I estimate the effects on the employment and on the natural interest rate of changes in market structure, proxied by an increase in the profits share. In particular, I consider a three-variable VAR for the US consisting of quarterly data for the sample period 1980q2 - 2015q1 for the growth of the profits share, the growth of employment (per capita) and the natural interest rate. I propose long-run restrictions as identification strategy based on two key assumptions: first, only exogenous shocks to the profits share, due to either technological or regulatory changes, affect the latter in the long-run; secondly, only shocks to the profits share and labor shocks may affect employment in the long-run. I focus on the impulse response functions to a permanent increase in the share of profits and I find that both the employment and the natural interest rate drop on impact and stabilize at a permanently lower level.

The remainder of the paper is organized as follows. In Section 1, I discuss the relation with the existing literature. In Section 2, I develop the baseline model with monopoly power, and I show that an increase in the profits share does trigger a decline in the interest rate and employment. I introduce the extended model in Section 3, and I provide a quantitative evaluation of the latter in Section 4. Finally, in Section 5, I discuss the empirical model and verify the testable implication. Conclusions follow.

1 Relation with the existing literature

From an empirical standpoint, the paper is related to two main strands of literature. On the one hand, it relates to the ever growing number of works investigating the ongoing changes in the structure of the market and their implications, as Autor et al. (2016, 2017), Kahle and Stulzs (2016), Karabarbounis L. and B. Neiman (2014a,b) Gutiérrez and Philippon (2016, 2017), Barkai (2017), Chen et al. (2017). On the other hand, the paper relates to the vaste literature on the equilibrium/neutral/natural interest rate, and its determinants. Though there are slight conceptual differences among the three definitions[6], I refer to the most generic "equilibrium" to mean "the equilibrium rate consistent with output at potential and price stability", Laubach and Williams (2003). As far as I know, there has been no attempt to investigate the relation between the market structure and the equilibrium interest rate. Laubach and Williams (2003, 2015) and Hamilton et al. (2015) consider the relation with the growth rate. Pescatori and Turunen (2015) builds on Laubach and Williams (2003) to estimate the natural rate and to assess the role of the global savings glut and policy uncertainty as its determinants. Rachel et al. (2015) consider also other determinants such as public investment, demographics,

[6]Williamson (2017) provides a brief discussion on this point.

inequality and, relative price of capital. Holston et al. (2016) and Gourinchas et al. (2016) focus on the international dimension. Hall (2016) consider the role of heterogeneity across investors. Del Negro et al. (2017) focus on the effect of the rise in the premium for safety and liquidity[7]. This paper contributes to the literature mainly in two ways. First, I use two established approaches to estimate the natural interest rate, respectively Laubach and Williams (2003) and Hamilton et al. (2015), but I focus on (a proxy for) the market structure as one of its determinants. Secondly, the novelty of my approach is to employ a structural VAR to estimate the effect of an increase in the profits share on the employment level and on the natural interest rate. A VAR approach has been employed recently by Kim (2016) to estimate the effects of changes in market structure on the labor share, and by Ferrero et al. (2017) to estimate the impact of adverse demographic developments on the key macroeconomic variables.

From a theoretical perspective, the paper is related to the literature on the causes of the decline of the natural interest rate, and it is highly close to Eggertsson et al. (2017) and Lisack et al. (2017). Eggertsson et al. (2017) build a 3 periods OLG model with nominal rigidities and they focus on the role of deleveraging, drop in population growth, rise in inequality, reduction in the price of capital and in the share of labor as triggers for Secular Stagnation. They introduce an exogenous markup in the final goods sector in the quantitative exercise to match the reduction in the labor share as one of the key moments in the data and they find that the reduction in labor share accounts only for a small share of the decline in the equilibrium interest rate. I depart from Eggertsson et al. (2017) for two key reasons. On the one hand, I consider the increase in market power to be the key reason behind the decline observed for both labor and capital, as empirically shown in Barkai (2017). On the other hand, I introduce labor market frictions, and I show that they can account for a large decrease in the interest rate, and for an amplification effect of shocks such as the increase in the profits share. Lisack et al. (2017) discuss the decline in the natural interest rate in a multi-periods OLG, mainly focusing on demographics. They show that also market structure matters, and so does the way profits are allocated

[7]Blanchard et al. (2017) add a twist on the Secular Stagnation hypothesis suggesting that pessimism about the future affects output and inflation through subdued demand and supply so that the interest rate undershoots the long run value.

among households. To abstract from this issue, I assume that profits are distributed to all individuals in their working age, proportionally to their labor income, indipendently on their status.

The paper is further related to the literature on the effects of monopolistic competition starting with the seminal papers by Dixit and Stiglitz (1977) and Blanchard and Kiyotaki (1987). Zeira (2010) builds a model of endogenous growth and he shows that monopoly power may impede growth, because of the downward pressure on wages, which is detrimental to growth. More recently, Barkai (2017) shows that a decrease in competition and in the interest rate explain lower labor and capital shares and greater output and investment gaps. Finally, Brun and González (2017) show that the wealth originated from lower capital taxes and the capitalization of monopoly rents crowds out capital formation. I show that declining competition can both explain the decline observed in the natural interest rate, and account for lower employment rate, lower wages and higher number of discouraged workers.

Finally, the paper is indebted to the literature on labor market frictions, and, in particular, to de la Croix et al. (2013). They build a multiperiods OLG framework with labor market frictions and they show that this setup delivers a strong connection between the interest rate and the unemployment rate. In particular, exogenous shocks, such as aging and pension reforms, leading to lower interest rates, also imply lower equilibrium unemployment rates, because lower capital costs stimulate labor demand and induce firms to advertise more vacancies. I depart from their work by introducing monopoly power within the production sector and by focusing on the implications of an increase in the latter. I assume that profits are distributed among working-age workers, proportionally to their labor income. Differently from de la Croix et al. (2013), I show that when the exogenous shock leading to lower interest rates concerns market structure and monopoly power, it will not imply also lower equilibrium unemployment rate.

2 A simple model

In this section, I develop a simple theoretical model to interpret the empirical evidence. I adopt a 3 periods OLG model and I allow for output to be endogenously determined, for monopoly power and for nominal rigidities. I assume that firms earn a constant, exogenous share of profits and I show that an increase in the latter puts a downward pressure on the equilibrium interest rate and it may trigger Secular Stagnation.

Households

Households live for 3 periods and they obtain income only in their middle age. In this case, they borrow when young from the middle-aged households and they save for retirement when middle-aged. Population grows at a rate $g_t = \frac{N_t}{N_{t-1}} - 1$, where N_t is the size of population at time t. Each individual seeks to maximize the following utility function:

$$\max U = \log C_t^y + \beta \log C_{t+1}^m + \beta^2 \log C_{t+2}^o \tag{1}$$

where β is the subjective discount factor, and C_t^y, C_{t+1}^m and C_{t+2}^o are the consumptions of the household when young, middle-aged and old. The household faces the following budget constraints

$$C_t^y = B_t^y \tag{2}$$

$$C_{t+1}^m + K_{t+1} + (1+r_t)B_t^y = w_{t+1}L_{t+1} + r_{t+1}^k K_{t+1} + Z_{t+1} + B_{t+1}^m \tag{3}$$

$$C_{t+2}^o + (1+r_{t+1})B_{t+1}^m = (1-\delta)K_{t+1} \tag{4}$$

$$(1+r_t)B_t^y \leq D_t \tag{5}$$

where Eq. (2), (3) and (4) are the budget constraints for the young, the middle and the old ages, and (5) is the borrowing constraint for the young. Consumption of the young equals B^y, which denotes borrowing. When middle-aged, the agent has two alternative assets for savings: he can either make loans to young households, or invest in capital that is rented to firms. Income for the middle-aged is composed of labor income, w_{t+1} is real wage, that is $w = \frac{W}{P}$ being W the nominal wage; return on capital, and profits. Capital is rented out in the same period as when investment takes place, enters as an input factor in the production function and has a real rental rate equal to r_t^k. When old, the agent consumes all his savings and the return from the sale of depreciated capital, where depreciation occurs at the rate δ. Concerning Eq. (5), I assume that the exogenous borrowing constraint for the young is always binding.

It is important to observe that how profits are allocated plays a key role for the results, as also Lisack et al. (2017) show. I assume that profits are distributed to the middle-aged agents, the saver in this economy.

Following the assumption about the borrowing limit, then the young agent is always financially constrained, and his consumption equals the limit:

$$C_t^y = \frac{D_t}{1+r_t} \tag{6}$$

Households' optimization implies:

$$\frac{1}{C_t^m} = \beta \frac{1+r_t}{C_{t+1}^o} \tag{7}$$

$$(1-r_t^k)C_{t+1}^o = \beta(1-\delta)C_t^m \tag{8}$$

Eq. (7) is the consumption Euler Equation, while Eq. (8) defines the optimal choice for capital. By no arbitrage, combining the two equations gives the relation between the rental rate and the real interest rate as follows:

$$1+r_t = \frac{(1-\delta)}{1-r_t^k} \tag{9}$$

I consider the case that agent has access also to riskless, one period nominal debt denominated in money. The asset is in zero net supply, and the government controls its return, the nominal interest rate. Implicitly, the existence of money[8] implies that there is a lower bound on the nominal rate, i.e. $i_t \geq 0$. The Euler Equation reads as follows

$$\frac{1}{C_t^m} = \frac{1}{C_{t+1}^o}(1+i_t)\frac{P_t}{P_{t+1}} \tag{10}$$

Final good producers

The final good producers buy intermediate goods, package Y_t, and resell it to consumers in a perfectly competitive market. In particular, they seek to maximize profits

$$\max P_t Y_t - \int_0^1 p_t(i) y_t(i) di \tag{11}$$

where $Y_t = (\int_0^1 y_t(i)^{\frac{\sigma-1}{\sigma}} di)^{\frac{\sigma}{\sigma-1}}$. P_t and $p_t(i)$ are the price of the final and intermediate goods respectively, where $P_t \equiv (\int_0^1 p_t(i)^{\sigma-1} di)^{\frac{1}{1-\sigma}}$. Maximization implies the following

[8]For a discussion about the introduction of money within an OLG framework, see Galì (2014.)

demand schedule for variety i:

$$p_t(i) = \left(\frac{y_t(i)}{Y_t}\right)^{-\frac{1}{\sigma}} P_t \tag{12}$$

Intermediate good producers

Following Zeira (2010), I assume that producers in the intermediate goods market have a monopoly power so that they earn a profit, proportional to output, $Z(i) = \hat{z}y(i)$. I assume that $\hat{z}$ is constant across i, which implies that market power is homogenous across sectors. Each firm maximizes profits

$$Z_t(i) = p_t(i)y_t(i) - W_t L_t(i) - r_t^k K_t(i) \tag{13}$$

subject to a Cobb Douglas production function, $y_t(i) = AK_t(i)^{1-\alpha}L_t(i)^{\alpha}$.

The first order conditions thus imply:

$$\frac{W}{p_t(i)} = (1-z)\alpha\frac{y_y(i)}{L_t(i)}$$
$$\frac{r^k}{p_t(i)} = (1-z)(1-\alpha)\frac{y_y(i)}{K_t(i)}$$

where $(1-z) = (1-\hat{z})(1-\frac{1}{\sigma})$. Notice that the higher is the share of profits, the lower is the real cost of inputs, $\frac{W_t}{p_t(i)}$ and $\frac{r_t^k}{p_t(i)}$. Given the symmetry of the model, all firms produce the same amounts, $y(i) = y(j) = Y$, and charge the same price, $p(i) = p(j) = P$ by Eq.(12). Letting K_t and L_t denote the aggregate capital stock and labor supply, it follows from the first order conditions above, that:

$$w_t = \frac{W_t}{P_t} = \left(1-z\right)\alpha\frac{Y_t}{L_t} \tag{14}$$
$$r_t^k = \left(1-z\right)(1-\alpha)\frac{Y_t}{K_t} \tag{15}$$

Monetary Policy

Monetary policy sets the nominal rate according to a standard Taylor rule:

$$1 + i_t = \max\left(1, (1+i^*)(\frac{\Pi_t}{\Pi^*})^{\phi_\pi}\right) \tag{16}$$

I set $\Pi^* = 1$ and $i^* = 0$, so that the zero lower bound for the steady state nominal rate, $i \geq 0$, binds at $\Pi = 1$.

2.1 Equilibrium

Labor Market

When wages are fully flexible, equilibrium labor equals fixed supply, $\bar{L}$. However, I assume the presence of a downward nominal wage rigidity constraint. The existence of wage rigidities has been mainstremed to be a key issue in the *Hysteresis* literature, being one of the reasons why shocks that generate unemployment may have long-term effects. Blanchard and Summers (1986) show that wage bargaining, a key feature of labor markets, can help explain the substantial unemployment persistence. In particular, I assume that nominal wages can never fall below the wage norm, $\tilde{W}_t$:

$$W_t = \max \left\{ \tilde{W}_t, P_t w_t^f \right\}$$

where w_t^f is the real wage that would prevail in the flexible wages economy, defined as follows

$$w_t^f = \left(1 - z\right) \alpha A K_t^{1-\alpha} \bar{L}^{\alpha-1}$$

and $\tilde{w}_t = \frac{\tilde{W}_t}{P_t}$ is such that

$$\tilde{w}_t = \gamma \frac{w_{t-1}}{\Pi_t} + (1-\gamma) w_t^f$$

Asset Market

Equilibrium in the market for loans requires that borrowing of the young equals the savings of the middle-aged so that

$$N_t B_t^y = -N_{t-1} B_t^m$$

or, equivalently,

$$(1 + g_t) B_t^y = -B_t^m \tag{17}$$

where I have normalized by middle-aged population size. I label the left-hand side as demand of loans, L_t^d, and the right hand side as supply of loans, L_t^s. Demand comes from the young, constrained agents, while supply of loans depends on total lending from middle-aged agents. Thus, equilibrium can be rewritten as

$$L_t^d = L_t^s$$

where

$$L_t^d = (1+g_t)B_t^y = \frac{1+g_t}{1+r_t}D_t \tag{18}$$

$$L_t^s = -B_t^m = \frac{\beta}{1+\beta}(Y_t - D_{t-1}) - \frac{\beta}{1+\beta}\left(1 + \frac{1}{\beta(1+r_t)}\right)K_t \tag{19}$$

where I have used Eq. (5) to derive the demand schedule and the Euler Equation, Eq. (7), together with the budget constraints, Eqs. (3) and (4), to derive the supply schedule. Demand of loans is a negative function of the interest rate, while it is a positive function of the exogenous borrowing limit, D_t, and growth rate. Supply of loans is an increasing function of the discount factor, β, net income, and interest rate, while it is negatively affected by the available stock of capital. Ceteris paribus, an increase in the available stock of capital reduces supply in the market for loans.

Equilibrium in the market for capital is such that households are willing to purchase any amount of capital for a given real rental rate which satisfies the no-arbitrage condition, Eq. (9). The equilibrium amount of capital is pinned down by firms' demand which can be recovered through Eq. (15). For future reference, demand for capital is negatively related to the share of profits.

By combining (18) and (19), I get the equilibrium interest rate for the loans market:

$$1 + r_t = \frac{1+\beta}{\beta}\frac{(1+g_t)D_t + \frac{(1-\delta)}{1+\beta}K_t}{Y_t - D_{t-1} - K_t} \tag{20}$$

For later use, the equilibrium interest rate is a positive function of capital. This follows from the fact that, ceteris paribus, an increase in capital reduces supply in the market for loans, putting an upward pressure on the interest rate. At this point it is useful to clarify that Eq. (20), evaluated at output equal to its potential, defines the natural interest rate, r^f, that is the interest rate consistent with full employment in equilibrium. By substituting out for capital, it follows that the natural interest rate is a negative function of monopoly power. Finally, equilibrium in the goods market follows by Walras' law.

The *equilibrium* is a set of quantities $\{Y_t, L_t, C_t^m, C_t^o, B_t^m, K_t\}_{t=0}^{\infty}$ and prices $\{i_t, \Pi_t, r_t^k, w_t\}_{t=0}^{\infty}$, given exogenous processes for $\{g_t, D_t\}_{t=0}^{\infty}$ that satisfy households' optimization, Eqs (7) and (8), together with budget constraints; firms' optimization, Eqs. (14) and (15) given the production function, and; monetary policy rule. Market clearing conditions hold.

2.2 Steady State

I consider the steady states of the economy. There are two scenarios, depending on whether the gross inflation rate is greater or lower than 1. On the AS side, the downward nominal wage rigidity constraint binds when the steady state features a negative inflation rate, that is $\Pi < 1$. Thus, labor is rationed. In fact, if the downward nominal wage rigidity is binding, the following equation holds:

$$w_t = \gamma \frac{w_{t-1}}{\Pi_t} + (1-\gamma) w_t^f$$

By combining the latter with Eq. (14) and the definition for the flexible wage, w_t^f, and evaluating the resulting expression at the steady state such that $K_t = K_{t-1} = K$ and $L_{t-1} = L_t = L$, I get the following relation between the steady state equilibrium labor and inflation:

$$L^{\alpha-1}(1 - \frac{\gamma}{\Pi}) = (1-\gamma)\bar{L}^{\alpha-1}$$

When labor is rationed, the steady state equilibrium level of employment is below full employment, that is $L < \bar{L}$, and it must be that $(\frac{1-\frac{\gamma}{\Pi}}{1-\gamma})^{\frac{1}{1-\alpha}} < 1$ which implies $\Pi < 1$. By construction whether the constraint on wages is binding or not depends only on the degree of flexibility in the labor market, that is the parameter γ, and on the gross inflation rate.

On the AD side, by assumption, the zero lower bound constraint for monetary policy initially binds as $\Pi < 1$. In general the kink of the aggregate demand curve occurs at the inflation rate at which the zero lower bound constraints monetary policy, that is $\Pi_{kink} = \left(\frac{1}{1+i^*}\right)^{\frac{1}{\phi_\pi}} \Pi^*$.

Therefore if $\Pi > 1$, the economy is described by the following set of conditions:

$$r^k = \left(1 - \frac{(1-\delta)}{1+r}\right)$$

$$r^k = (1-\alpha)\left(1-z\right)\frac{Y}{K}$$

$$Y = AK^{1-\alpha}\bar{L}^{\alpha}$$

$$Y = D + \frac{1+\beta}{\beta}\frac{1+g}{1+r}D + K\left(1 + \frac{(1-\delta)}{\beta(1+r)}\right)$$

where, by the policy rule, inflation is such that $1 + r = \Pi^{\phi_\pi - 1}$. The fact that the steady state marginal product of capital cannot to be negative, $r^k \geq 0$, implies that

$$r \geq -\delta$$

Observe that the assumption of a positive rate of depreciation is key to avoid a zero lower bound on the real interest rate. In the absence of depreciation, capital would act as a perfect storage of wealth thus imposing a zero lower bound on the real interest rate as well.

If $\Pi < 1$, instead, the economy is described by the following set of conditions:

$$L = \left(\frac{1 - \frac{\gamma}{\Pi}}{1-\gamma}\right)^{\frac{1}{1-\alpha}}\bar{L}$$

$$r^k = \left(1 - \Pi(1-\delta)\right)$$

$$r^k = (1-\alpha)\left(1-z\right)\frac{Y}{K}$$

$$Y = AK^{1-\alpha}L^{\alpha}$$

$$Y = D + \frac{1+\beta}{\beta}(1+g)\Pi D + K\left(1 + \frac{\Pi}{\beta}(1-\delta)\right)$$

I solve the model in both cases by substituting out for K, L r^k and r to obtain the two equations in the two endogenous, Y and Π. For future reference, consider the steady state level of capital obtained by combining the first two equations for the scenario $\Pi > 1$, or the second and third ones for the scenario $\Pi < 1$:

$$K = \left(1-z\right)(1-\alpha)(1 - \frac{1-\delta}{1+r})^{-1}Y \tag{21}$$

It follows that the steady state equilibrium level of capital is negatively related to the profits share. An increase in the latter measures a larger gap between the marginal productivity of capital and its rental rate, hence lowering demand for capital. Eq. (21) offers also an insight on the behaviour of the capital share. In particular,

$$\frac{K}{Y} = \frac{(1-z)(1-\alpha)}{1-\frac{1-\delta}{1+r}} \tag{22}$$

For further reference, notice that the capital share is decreasing in both the profits share and in the interest rate.

2.3 A change in market structure

Consider the parameters as listed in Table 4, Column 1. I assume that the nominal interest rate is consistent with the Taylor rule, $1 + i^* = (1 + r^f)\Pi^*$, where r^f is the natural interest rate as defined by Eq. (20) evaluated at full employment. By this assumption, it follows that any shock affecting the natural interest rate will alter the kink of the aggregate demand curve. Consider an increase in the share of profits earned by the monopolist firms. In particular, z increases from 0.1 to 0.5. Figure 1 shows the aggregate demand and supply schedules and the equilibrium, before and after the shock has occurred. As market power increases, both the AD and AS curves shift leftwards. The economy goes from Full Employment, point A in Figure 1, to Secular Stagnation, point B. The transition to the new steady state equilibrium is thus explained by changes in both sides of the economy. From the supply side, there are two forces at work. Consider the upper portion of the AS schedule, and potential output as defined by the following equation:

$$Y = A^{\frac{1}{\alpha}}\left[(1-z)(1-\alpha)(1-\frac{1-\delta}{1+r})^{-1}\right]^{\frac{1-\alpha}{\alpha}}\bar{L}$$

where I have substituted out for capital using Equation (21) within the production function. As the above equation makes clear, an increase in the share of profits reduces capital and thus potential output, for a given level of inflation. Therefore, the AS curve moves leftwards. Moreover, aggregate supply is further reduced due to an aggregate demand externality. On the AD side, the increase in market power triggers a drop in the natural interest rate and the kink of the AD curve moves inwards. Indeed, as Eq. (20) shows, the natural interest rate negatively depends on the equilibrium level of capital. This result follows from the facts that the equilibrium in the market for loans and,

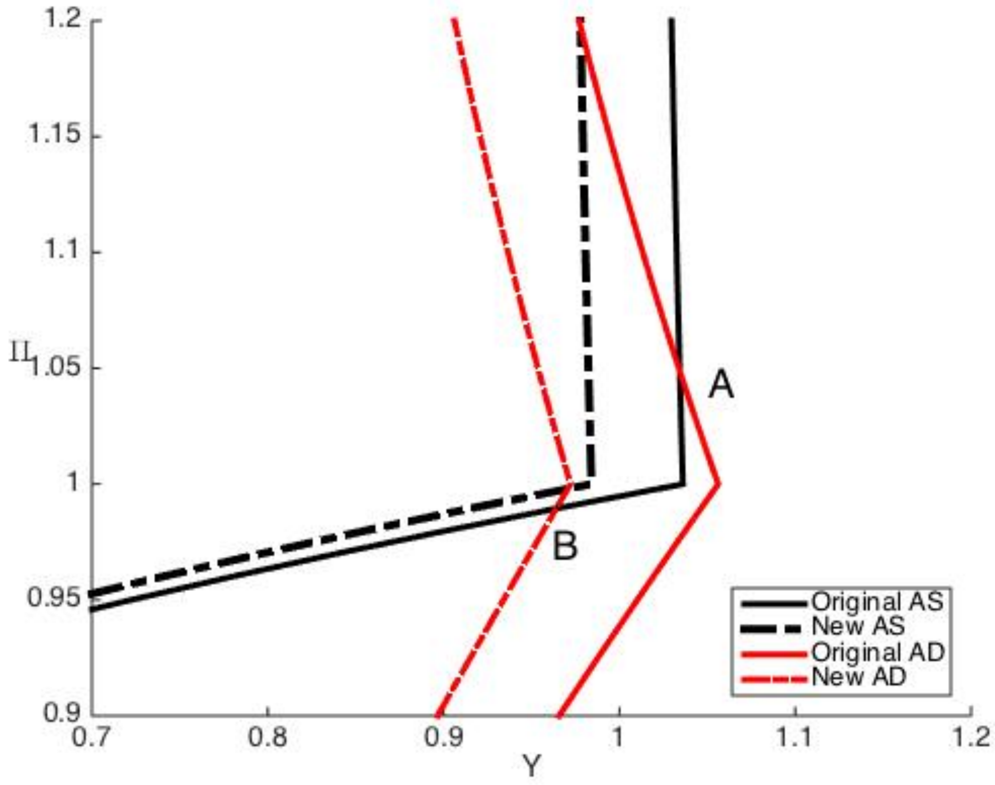


Figure 1: Effects of a change in market structure in the baseline model with monopoly power. The solid lines represent the AS and the AD schedules before the shock, and the original steady state is in A. As the profits share increases, both the AS and the AD schedules move leftwards, the dashed lines. The economy moves to new steady state, B.

specifically, the loans supply schedule, Eq. (19), depend on the available stock of capital. Thus, the decrease in the steady state level of capital increases the supply of loans, putting a downward pressure on the equilibrium interest rate for loans. In particular, following the increase in the profits share from 0.1 to 0.5, the natural interest rate declines by 6% and eventually lands in negative territory. The existence of the zero lower bound, however, prevents the rate from adjusting and, altogether with the consequent deflation, have two key implications. Since it raises the real wage and rental rate of capital, it further depresses firms' demand for inputs and equilibrium output. Moreover, since the interest rate cannot properly adjust, the capital share does not sufficiently increase, as by Eq. (21), and is lower than expected. In conclusion, a deep change in the market structure, captured by an increase in the profits share, does affect both the supply and demand sides of the economy, and it pushes the economy away from the full employment equilibrium, eventually triggering Secular Stagnation.

3 An extended model

I extend the model to allow for standard labor market frictions à la Diamond, Mortenses and Pissarides, with exogenous job destruction and a matching function. There is perfect substitutability between all workers, a single matching function, and age-dependent labor productivity. I follow de la Croix et al. (2013) that incorporate labor market frictions within a multi-periods OLG model. I depart from their setup by allowing for monopoly power within the intermediate goods production sector of the economy. The focus of the analysis is on the impact of an increase in monopoly power on the key macroeconomic, financial and labor market variables, and on the role of labor market frictions.

3.1 Demographics

Each member of a given cohort can live up to 16 five-year periods (from age 25 to 104) indexed from 0 to 15. Let $\Psi_{a,t}$ denote the size of the cohort reaching age a at time t. The size of each cohort declines deterministically[9] through time so that $\Psi_{a,t+a} = \rho_{a,t+a}\Psi_{0,t}$ for all $a \; \epsilon[1, 2..15]$. The term $\rho_{a,t+a} \; \epsilon[0, 1]$ is the survival probability, assumed to be decreasing in a and such that $\rho_{0,1} = 1$. Total (adult) population at time t is equal to $\Psi_t = \sum_{a=0}^{15} \Psi_{a,t}$.

The population of working age is defined as $P_{a,t+a} = \psi_{a,t+a}\Psi_{a,t+a}$ where $\psi_{a,t+a} = 1$ for $a \; \epsilon[0, 7]$, 0 otherwise. I allow for mandatory retirement at age 65, for exogenous partecipation rate (normalized to unity) between 25 and 54, and for early retirement between 55 and 64. This implies that early retirees, in this model, can be interpreted as the discouraged workers. At any point in time, people of working age are either employed (N), unemployed (U), or on an early retirement scheme (E):

$$P_{a,t} = N_{a,t} + U_{a,t} + E_{a,t} = \Big[n_{a,t} + u_{a,t} + e_{a,t}\Big] P_{a,t} \;\; \forall \;\; a \;\; \epsilon \;\; [0, 7]$$

[9]The size of the cohort may also change over time, due to fertility and migration shocks. I abstract from demographic shocks.

where lower case letters denote the share of individuals in each group. Early-retirement share is zero before age 55. Let $\lambda_{6,t}$ denote the fraction of people who choose early retirement between 55 and 60, then $E_{6,t} = \lambda_{6,t} P_{6,t}$; similarly, $\lambda_{7,t}$ denotes early retirees between 60 and 65. Thus, the total number of early retirees at a given t is

$$E_{6,t} + E_{7,t} = e_{6,t} P_{6,t} + e_{7,t} P_{7,t}$$

where

$$e_{6,t} = \lambda_{6,t} \tag{23}$$

$$e_{7,t} = \lambda_{6,t-1} + \lambda_{7,t}(1 - \lambda_{6,t-1}) \tag{24}$$

3.2 Labor market

I introduce labor market frictions, namely exogenous job destruction and a matching function. Following Pissarides (2000), I assume that there is a matching function which depends on the number of workers looking for a job and on the number of vacancies posted by firms. Households which are employed do not look for a job (no on-the-job search), and firms don't look for workers for occupied vacancies. The matching function gives the number of jobs formed at any time, according to the following Cobb Douglas:

$$M = \bar{m} V_t^{1-\nu} Q_t^{\nu}; \tag{25}$$

where V_t is the total number of vacancies and Q_t is the number of job seekers at the beginning of time t. The number of job seekers for $a = 0$ is given by the whole cohort. For $a = 1, ..5$, job seekers are those who were previously employed and then lost their jobs. Finally, for $a = 6, 7$, job seekers are those who don't choose early retirement among the ones who lost their jobs. The job destruction rate is constant and exogenous, equal to χ. Analytically, Q_t is defined as follows

$$Q_t = \sum_{a=0}^{7} Q_{a,t} = P_{0,t} + \sum_{a=1}^{5} [1 - (1-\chi) n_{a-1,t-a}] P_{a,t} +$$
$$+ [1 - (1-\chi) n_{5,t-1}](1 - \lambda_{6,t}) P_{6,t} + [(1 - \lambda_{6,t}) - (1-\chi) n_{6,t-1}](1 - \lambda_{7,t}) P_{6,t}$$

where χ is the exogenous job destruction rate.

The probability of finding a job, p_t, is the ratio of total matches over the number of job seekers, that is

$$p_t = \frac{M_t}{Q_t} \tag{26}$$

while the probability of filling a vacancy, v_t, is the number of matches over the number of available vacancies, that is

$$v_t = \frac{M_t}{V_t} \tag{27}$$

For further reference, observe that combining (26) and (27) gives the following relation between the two probabilities:

$$p_t = v_t \frac{V_t}{Q_t} \tag{28}$$

Observe that, for a given p_t, the probability of filling a vacancy is decreasing in market tightness, where the latter is captured by the ratio of the number of job seekers over available vacancies. Finally, the number of employed workers in age group a is the sum of non-destroyed jobs and new hires:

$$\begin{aligned} n_{a,t} &= p_t \frac{Q_{a,t}}{P_{a,t}} \quad \text{for} \quad a = 0 \\ n_{a,t} &= (1-\chi) n_{a-1,t-a} + p_t \frac{Q_{a,t}}{P_{a,t}} \quad \text{for} \quad a \; \epsilon \; [1,5] \\ n_{a,t} &= (1-\lambda_{a,t})(1-\chi) n_{a-1,t-1} + p_t \frac{Q_{a,t}}{P_{a,t}} \quad \text{for} \quad a \; \epsilon \; [6,7] \end{aligned} \tag{29}$$

Total employment N_t equals $\sum_{a=0}^{7} N_{a,t}$, with $N_{a,t} = n_{a,t} P_{a,t}$.

3.3 Households

The household's decision variables are consumption, saving and early retirement rates, subject to the lifetime budget constraint. There is no aggregate uncertainty, and perfect foresight is assumed. Moreover, there is perfect insurance against the adverse effects of individual lifetime uncertainty. There are no bequests. The objective function of the househould, W_t^H, is defined as follows:

$$\begin{aligned} W_t^H = \max_{c_{a,t+a}, \lambda_{6,t+a}, \lambda_{7,t+7}} \sum_{a=0}^{15} \left(\frac{1}{1+\beta} \right)^a \rho_{a,t+a} \Big\{ & ln(c_{a,t+a}) + \\ & - d^n n_{a,t+a} \psi_{a,t+a} + u_a^e \frac{(e_{a,t+a})^{1-\phi}}{1+\phi} \psi_{a,t+a} \Big\} \Psi_{0,t} \end{aligned} \tag{30}$$

where β is the subjective discount rate, $\rho_{a,t+a}$ is the cumulative survival probability, $\psi_{a,t+a}$ is the working age dummy variable and $\Psi_{0,t}$ is the initial size of the cohort. The utility is assumed to be separable and logarithmic for consumption. The marginal disutility from working is constant and equal to d^n, while the extra utility from early retirement is concave in $e_{a,t+a}$. The household's optimization is subject to the flow budget constraint at time $t+a$ that takes the following form:

$$\Big[(1-\tau^w_{t+a})w_{a,t+a}n_{a,t+a} + b^u_{a,t+a}u_{a,t+a} + b^e_{a,t+a}e_{a,t+a}\Big]\psi_{a,t+a} + b^z_{a,t+a}\psi_{a,t+a}$$
$$b^i_{a,t+a}(1-\psi_{a,t+a}) + R_{t,t+a}s_{a-1,t+a-1} = (1+\tau^c_{t+a})c_{a,t+a} + s_{a,t+a} \quad (31)$$

where $\tau^w_{t+a}, \tau^c_{t+a}$ are labor income and consumption tax rates; $b^u_{a,t+a}, b^e_{a,t+a}, b^i_{a,t+a}$ are benefits received by the unemployed, the early retiree, and the retired; $b^z_{a,t+a}$ is the share of distributed profits; $s_{a,t+a}$ is financial wealth accumulated at time $t+a$ in per capita terms[10]. Because of the perfect insurance assumption, the total return, $R_{t,t+a}$, is equal to $\frac{\rho_{a-1,t+a-1}}{\rho_{a,t+a}}R_{t+a}$, that is the gross risk-free interest rate, R_{t+a}, divided by the survival probability. There are no bequest and initial financial wealth is zero. Unemployment and retirement benefits are modeled following the US Social Security system[11]. Moreover, households of age a receive a share of firms' pure profits during their working age, i.e. for a $[0,7]$, independently on their status (employed, unemployed or early retirees), hence implying that their decisions are affected only to the extent that they experience an increase in disposable income[12]. Profits are distributed to households of age a proportionally to the labor income accrued by workers of age a out of total labor income in $t+a$.

Optimality conditions follows from the maximization of (30) subject to the intertemporal budget constraint, given $n_{a,t}, e_{a,t}$ as by Eqs. (23), (24), (29). By optimality,

[10] I abstract from the existence of borrowing constraints of the kind introduced in the simple model. Households may be constrained by a limit of the kind $s_{a,t+a} \geq \frac{D_t}{R_{t+a}}$.

[11] Feldstein and Liebman (2002) provide a detailed analysis of how Social Security works.

[12] The assumption about how profits are distributed implies that households receive this extra income added on the top of the wage, of the early retirement benefit and of the unemployment benefit depending on whether the household of age a is employed, on an early retirement scheme or unemployed. This implies that the early retirement decision, for example, still depends only on the differential between the net benefits, namely net of the distributed profits.

the standard Euler Equation must hold:

$$\frac{C_{a+1,t+a+1}}{C_{a,t+a}}\frac{1+\tau^c_{t+a+1}}{1+\tau^c_{t+a}}=\frac{R_{t+a+1}}{1+\beta}$$

The early retirement at $a=6$ must satisfy

$$\begin{aligned}\left[\frac{b^e_{a,t+a}-b^u_{a,t+a}}{(1+\tau^c_{t+a})c_{a,t+a}}+u^e_a(e_{a,t+a})^{-\phi}\right](1-e_{a,t+a})+\frac{1}{1+\beta}\frac{\rho_{a+1,t+a+1}}{\rho_{a,t+a}}\left[\frac{b^e_{a+1,t+a+1}-b^u_{a+1,t+a+1}}{(1+\tau^c_{t+a+1})c_{a+1,t+a+1}}+\right.\\ \left.+u^e_{a+1}(e_{a+1,t+a+1})^{-\phi}\right](1-e_{a+1,t+a+1})=\\ n_{a,t+a}\left[\frac{(1-\tau^w_{t+a})w_{a,t+a}-b^u_{a,t+a}}{(1+\tau^c_{t+a})c_{a,t+a}}-d^n\right]+\\ \frac{1}{1+\beta}\frac{\rho_{a+1,t+a+1}}{\rho_{a,t+a}}n_{a+1,t+a+1}\left[\frac{(1-\tau^w_{t+a+1})w_{a+1,t+a+1}-b^u_{a+1,t+a+1}}{(1+\tau^c_{t+a+1})c_{a+1,t+a+1}}-d^n\right]\end{aligned} \quad (32)$$

while, at age $a=7$

$$\left[\frac{b^e_{a,t+a}-b^u_{a,t+a}}{(1+\tau^c_{t+a})c_{a,t+a}}+u^e_a(e_{a,t+a})^{-\phi}\right](1-e_{a,t+a})=n_{a,t+a}\left[\frac{(1-\tau^w_{t+a})w_{a,t+a}-b^u_{a,t+a}}{(1+\tau^c_{t+a})c_{a,t+a}}-d^n\right] \quad (33)$$

For later use, note that the value of an additional job for a worker of age a is

$$\begin{aligned}\frac{\partial W^H_t}{\partial N_{a,t}}&=\frac{1}{\psi_{a,t}\Psi_{a,t}}\frac{\partial W^H_t}{\partial n_{a,t}}\\ &=\sum_{j=0}^{7-a}\frac{\rho_{a+j,t+j}}{\rho_{a,t}}\left(\frac{1}{1+\beta}\right)^j\left\{\frac{(1-\tau^w_{t+j})w_{a+j,t+j}-b^u_{a+j,t+j}}{(1+\tau^c_{t+j})C_{a+j,t+j}}-d^n\}\right\}\frac{\partial n_{a+j,t+j}}{\partial n_{a,t}}\end{aligned} \quad (34)$$

3.4 Firms

As in the simple model, there are final and intermediate goods firms. The former are modeled following the simple model, while the modeling strategy for the firm i in the intermediate goods sector is extended following de la Croix et al. (2013). In particular, let H_t denote labor input in efficiency units:

$$H_t(i)=\sum_{a=0}^{7}h_{a,t}N_{a,t}(i) \quad (35)$$

Production function is constant return to scale in labor and capital:

$$Y_t(i)=F(K_t(i),H_t(i))=A_tH_t(i)^{\alpha}K_t(i)^{1-\alpha} \quad (36)$$

Firms rent capital at cost $r_t^k = R_t + \delta - 1$ and pay a gross wage $w_{a,t}$ to workers of age a. Denote by ζ_t the employer wage tax. Firms' real profits at time t are defined as follows

$$Z_t(i) = F(K_t(i), H_t(i)) - r_t^k K_t(i) - \sum_{a=0}^{7}(1+\zeta_t)w_{a,t}N_{a,t}(i) - a_v V_t(i) \tag{37}$$

where $Z_t(i) = \hat{z}y_t(i)$, and a_v is the cost of posting a vacancy.

The value of a representative intermediate goods producer is thus

$$W_t^F = \max_{K_t, V_t}\{F(K_t, H_t) - r_t^k K_t - \sum_{a=0}^{7}(1+\zeta_t)w_{a,t}N_{a,t} - a_v V_t\} + R_{t+1}^{-1}W_{t+1}^F \tag{38}$$

given $N_t = v_t V_t \frac{\Omega_{a,t}}{\Omega}$. Maximization is subject to Eqs (28) and (29).

Optimality conditions are

$$r_t^k = (1-z)A_t^{\alpha}\left(\frac{H}{K}\right)^{1-\alpha} \tag{39}$$

$$a_v = v_t \sum_{a=0}^{7} \frac{Q_{a,t}}{Q_t}\frac{\partial W_t^F}{\partial N_{a,t}} \tag{40}$$

where the value at time t of an additional worker of age a is given by

$$\begin{aligned}
\frac{\partial W_t^F}{\partial N_{7,t}} &= h_{7,t}F_H - (1+\zeta_t)w_{7,t} \\
\frac{\partial W_t^F}{\partial N_{6,t}} &= h_{6,t}F_H - (1+\zeta_t)w_{6,t} + \rho_{7,t+1}R_{t+1}^{-1}(1-\chi)(1-\lambda_{7,t+1})\frac{\partial W_{t+1}^F}{\partial N_{7,t+1}} \\
\frac{\partial W_t^F}{\partial N_{5,t}} &= h_{5,t}F_H - (1+\zeta_t)w_{5,t} + \rho_{5,t+1}R_{t+1}^{-1}(1-\chi)(1-\lambda_{6,t+1})\frac{\partial W_{t+1}^F}{\partial N_{6,t+1}} \\
\frac{\partial W_t^F}{\partial N_{4,t}} &= h_{4,t}F_H - (1+\zeta_t)w_{4,t} + \rho_{5,t+1}R_{t+1}^{-1}(1-\chi)\frac{\partial W_{t+1}^F}{\partial N_{5,t+1}} \\
\frac{\partial W_t^F}{\partial N_{3,t}} &= h_{3,t}F_H - (1+\zeta_t)w_{3,t} + \rho_{3,t+1}R_{t+1}^{-1}(1-\chi)\frac{\partial W_{t+1}^F}{\partial N_{4,t+1}} \\
\frac{\partial W_t^F}{\partial N_{2,t}} &= h_{2,t}F_H - (1+\zeta_t)w_{2,t} + \rho_{2,t+1}R_{t+1}^{-1}(1-\chi)\frac{\partial W_{t+1}^F}{\partial N_{3,t+1}} \\
\frac{\partial W_t^F}{\partial N_{1,t}} &= h_{1,t}F_H - (1+\zeta_t)w_{1,t} + \rho_{2,t+1}R_{t+1}^{-1}(1-\chi)\frac{\partial W_{t+1}^F}{\partial N_{2,t+1}} \\
\frac{\partial W_t^F}{\partial N_{0,t}} &= h_{0,t}F_H - (1+\zeta_t)w_{0,t} + \rho_{1,t+1}R_{t+1}^{-1}(1-\chi)\frac{\partial W_{t+1}^F}{\partial N_{1,t+1}}
\end{aligned} \tag{41}$$

given that the marginal productivity of human capital is constant across a and equals

$$F_H = (1-z)A_t^{1-\alpha}\left(\frac{K}{H}\right)^{\alpha} \tag{42}$$

It is immediate to notice that, as in the baseline model, an increase in the profits share, z, puts a downward pressure on firms' demand for the two inputs. Pure profits are then returned to households in working-age, proportionally to their labor income. There is no market for firms' shares, thus the only available (outside) asset for households' savings is capital[13].

3.5 Government

Unemployment and retirement benefits are computed as exogenous fractions of the current gross wage for worker of age a, while the retirement benefit depends on the average wage earned during the previous 20 years (four periods):

$$b^u_{a,t} = \rho^u_t w_{a,t} \quad \text{for} \quad 0 \leq a \leq 7 \tag{43}$$

$$b^e_{a,t} = \rho^e_t w_{a,t} \quad \text{for} \quad 6 \leq a \leq 7 \tag{44}$$

$$b^i_{a,t} = \rho^i_t \sum_{i=0}^{3} \frac{w_{a-i,t-i}}{4} \quad \text{for} \quad 8 \leq a \leq 15 \tag{45}$$

Total transfer expenditures are then equal to

$$T_t = \rho^u_t \sum_{a=0}^{7} w_{a,t} u_{a,t} \Psi_{a,t} + \rho^e_t \sum_{a=6}^{7} w_{a,t} e_{a,t} \Psi_{a,t} + \rho^i_t \sum_{i=0}^{3} \frac{w_{a-i,t-i}}{4} \sum_{a=8}^{15} \Psi_{a,t} \tag{46}$$

Public consumption is assumed to be an exogenous fraction of net income:

$$G_t = \bar{g}(Y_t - a_v V_t) \tag{47}$$

Moreover, government balances its budget every period by adjusting τ^c_t:

$$\tau^c_t C_t + (\tau^w_t + \zeta_t)\left(\sum_a w_{a,t} n_{a,t} P_{a,t} \right) = G_t + T_t \tag{48}$$

There is no public debt.

3.6 Wage Bargaining

The wage bargaining identifies the wage that maximizes the weighted product of the households' and the firms' marginal benefit from an additional job. I assume that the

[13] Results are robust to this alternative specification.

bargaining process is symmetric, thus bargaining power is constant and equal across households and firms. In particular, as in Kitao et al. (2010), the worker's relative bargaining power is 0.5 and wages are renegotiated in every period, according to the following Nash bargaining rule, that is a Cobb Douglas with equal weights:

$$\max_{w_{a,t}} \left(\frac{\partial W_t^F}{\partial N_{a,t}}\right)^{\frac{1}{2}} \left(\frac{\partial W_t^H}{\partial N_{a,t}}\right)^{\frac{1}{2}} \tag{49}$$

where $\frac{\partial W_t^F}{\partial N_{a,t}}$ is given by Eq. (41) and $\frac{\partial W_t^F}{\partial N_{a,t}}$ by Eq. (34).
The first-order optimality condition can be written as follows:

$$\frac{\partial W_t^H}{\partial N_{a,t}} = \frac{1-\tau_t^W}{(1+\zeta_t)(1+\tau_t^c)} \frac{\partial W_t^F}{\partial N_{a,t}} \tag{50}$$

3.7 Intertemporal general equilibrium

In line with de la Croix et al. (2013), I will consider the two versions of the model, depending on whether there are frictions in the labor market.

Consider the following exogenous processes for

- demographics: $\rho_{a,t}$, for $t = 0, 1, .. + \infty$ and $a = 0, 1, ..15$;
- policy variables: $\rho_t^u, \rho_t^e, \rho_t^i$ and τ_t^w, ζ_t for $t = 0, 1, .. + \infty$;

and initial conditions $\Psi_{a,-1}$ for $a = 0, 1..15$, assets $s_{a,-1}$ for $a = 0, 1, ..14$ and capital stock $\bar{K}_0 < \sum_{a=0}^{14} s_{a,-1}\Psi_{a,-1}$.

Intertemporal equilibrium with flexible labor market

An intertemporal equilibrium with perfect foresight and flexible labor market is such that:

1. saving, consumption and early retirement decisions maximize households' utility, Eq. (30), subject to the constraint (31);
2. capital, posted vacancies and output satisfy firms' profits maximization, given initial condition for capital, and $a_v = 0$;

3. there are no frictions in the labor market, thus the number of new hires, M_t, satisfies $M_t = V_T$; the probabilities of finding a job and filling a vacancy are such that $v_t = p_t = 1$; $\chi = 0$ and the employment rates $n_{a,t}$ satisfy (29) for $t = 0, 1.. + \infty,.$;

4. total population, $\Psi_{a,t}$, working age population $P_{a,t}$, and job seekers, $Q_{a,t}$, satisfy the population dynamics for $a = 0, ..7$ and $t = 0, 1.. + \infty,.$;

5. wages, $w_{a,t}$ for $a = 0, ..7$, are such that

$$n_{a,t} + e_{a,t} = 1 \tag{51}$$

6. government benefits, b_t^e, b_t^i, follow the rules defined in Eq. (44) and (45), while $b_t^u = 0$, since there is no unemployment by construction. Government spending, G_t, satisfies Eq (47), for $t = 0, .. + \infty$;

7. consumption taxes, τ_t^c, satisfies balanced budget, Eq. (48);

8. the interest rate, R_t, satisfies financial market clearing condition

$$K_{t+1} = \sum_{a=0}^{14} s_{a,t} \Psi_{a,t} \tag{52}$$

Intertemporal equilibrium with labor market frictions

An intertemporal equilibrium with perfect foresight and labor market frictions is such that:

1. saving, consumption and early retirement decisions maximize households' utility, Eq. (30), subject to the constraint (31);

2. capital, posted vacancies and output satisfy firms' profits maximization, given initial condition for capital;

3. the number of new hires, M_t, the probabilities of finding a job and filling a vacancy, p_t and v_t, and the employment rates $n_{a,t}$ satisfy the matching technology;

4. total population, $\Psi_{a,t}$, working age population $P_{a,t}$, and job seekers, $Q_{a,t}$, satisfy the population dynamics for $a = 0, ..7$ and $t = 0, 1.. + \infty,.$;

5. unemployment, $u_{a,t}$, is such that the following condition holds, for $a = 0, ..7$ and $t = 0, 1.. + \infty$

$$1 = n_{a,t} + u_{a,t} + e_{a,t} \tag{53}$$

6. wages, $w_{a,t}$ for $a = 0, ..7$ and $t = 0, 1.. + \infty$, are negotiated following the Nash bargaining rule, Eq. (49);

7. government benefits, b_t^u, b_t^e, b_t^i follow the rules defined in Eq. (43), (44) and (45), and government spending, G_t, satisfies Eq (47), for $t = 0, .. + \infty$;

8. consumption taxes, τ_t^c, satisfies balanced budget, Eq. (48);

9. the interest rate, R_t, satisfies financial market clearing condition, Eq. (52).

4 Quantitative evaluation of the extended model

The full nonlinear model is solved numerically. I solve first for the stationary equilibrium. Then, I solve for the perfect foresight transition paths. The focus is on the effect of an exogenous increase of the profits share, both in the economy with frictionless labor market, and in the one with bargaining and frictions.

4.1 Calibration

Calibration is synthetized in Table 1. The key target for the calibration is the equilibrium real interest rate. I have targeted the annual ex ante real interest rate for the U.S. in the late 80s, estimated and reported by Hamilton et al. (2015), whose methodology is explained in Section 5, and replicated, for a quarterly frequency, in Figure 2. The (average) ex ante annual real interest rate at the end of the 80s is around 5%. The chosen calibration delivers an interest rate equal to 7.44%, for the perfectly competitive scenario, with an extremely high employment rate, equal to 95.02%. Under frictions, instead, both the equilibrium interest rate and the employment rate are lower, equal to 5.49% and 84%, and both are closer to the actual values. The employment rate is close to the one observed in the late 80s in the US, for workers aged 25-54, around 80%, while

Symbol	Value	Symbol	Value
Production Function			
A	20	α	0.5
δ	0.096 (y)	z	0
Age-dependent Productivity			
h_0	2.70	h_1	3.30
h_2	3.85	h_3	4.45
h_4	5.00	h_5	5.80
h_6	5.60	h_7	5.50
Preferences			
β	0.9606 (y)	d^n	0.250
u_6^e	0.031	u_7^e	0.049
ϕ	0.80		
Labor market			
$\bar{m}$	0.85	ν	0.50
χ	0.33	a_v	100
Policy variables			
ζ	0.30	τ^w	0.15
$\bar{g}$	0.20	ρ^u	0.40
ρ^e	0.60	ρ^i	0.66

Table 1: Parameter Values

the employment rate for all workers is slightly lower, around 76%.

The demographic process, and the survival probabilities, are set to match the dependency ratio for the US, that is the ratio of people younger than 15 or older than 64 to the working-age population. Since the early 80s, the ratio has been pretty stable, around 50%. The calibrated dependency ratio in the model is 46%.

I assume that technology-related parameters are constant, to abstract from the effects of the latter on the equilibrium interest rate. The elasticity of output with respect to labor and capital is 0.5; TFP and age-dependent productivity are constant, and the latter increases with age until 50, then decreases; depreciation of capital is 2.5% per quarter, implying a value around 10% at annual frequency as in Jorgenson (1996) and Eggertsson et al. (2017). The profits share is zero in the initial steady state, and then rises to 12%. Barkai (2017) shows that the profits share has indeed increased by 12% in the last three decades.

Preferences-related parameters are standard. β is 0.10 quarterly, labor disutility for workers aged at most 50, 50-59 and 60-64 is, respectively, 0.25, 0.031 and 0.049. The implied Frish elasticity is equal to 0.60, given the value for ϕ equal to 0.80.

Concerning the labor market, calibration follows the standard in this field. The matching process is modeled as Cobb-Douglas function. The elasticity of matches with respect to vacancies, ν, is fixed at 0.50, as in Kitao et al. (2010) and common in the literature. The separation rate is 2% at a quarterly frequency, implying a value equal to 33% for a five-year period. The matching parameter, $\bar{m}$, and the vacancy cost, a_v, are set equal to 0.85 and 100, which are close to the calibration à la de la Croix et al. (2013), without imposing any constraint on the probabilities of finding a job and filling a vacancy.

Finally, among the policy variables, government spending equals the 20% of GDP, while the gross replacement rates are calibrated as follows. The replacement rate for unemployed is set to 0.4, slightly below the 2015 OECD median of the replacement rate for long-term unemployment. In the case of two-earner married couple, the US positions itself pretty close to the OECD median. The chosen calibration for ρ^u is also in line with Kitao et al. (2010) and Blundell et al. (2017). The replacement rate for late retirees is set equal to 0.66 to match the replacement rate for low earners who retire after 69, while the replacement rate for early retirees is set equal to 0.60. First of all, notice that the replacement rate for early retirees is higher than the one for long-term unemployment. This reflects the US system and potentially helps to explain why half of the Americans retire early, between 61 and 65. Secondly, notice that the replacement rate for early retirees is lower than the one for late retirees. According to the US Social Security system, the earlier an individual starts receiving the retirement benefit, the lower the latter will be. Conversely, if an individual chooses getting delayed benefits, he will increase his monthly benefits. Despite of these incentives and of the retirement income crisis, Americans have not changed yet their attitude towards early retirement[14]. Although there has been a slight increase in the retirement age in the last years, labor force partecipation rate for 55 and over is stable at 40% vs 81.7% of those aged 25-54 (Source: U.S. Bureau of Labor Statistics). Retirement benefits are based on a reference wage, that is the average wage of the previous 20 years, computed as the average wage earned by workers aged 45-64. Wage income tax is set equal to 0.30, as in Kitao et al. (2010).

Table 2 reports the initial steady state values for the two key variables, under the two labor market scenarios, before the shock. The annual interest rate in the frictionless economy is 7.44%. The same calibration delivers a lower interest rate under labor market frictions. Concerning the employment rate, we observe that its value is close to the unity with perfectly competitive labor market, in line with the theoretical construction. As we move to the other scenario, instead, the employment rate decreases to 84.06%. Thus, the introduction of labor market frictions, ceteris paribus, is associated with a permanently lower equilibrium interest rate and employment rate.

4.2 A change in market structure

I consider an increase in the profits share by 12 p.p. Table 2 shows the change in the steady state values for the interest rate and the employment rate, across the two scenarios. Under perfectly competitive labor markets, the interest rate and the employment rate drop, respectively, by 1.3 and 0.4 pp. Under frictions, the drop observed for the interest rate is about 1 pp, while the decline in the employment rate is much bigger, 11.65 pp. The former model thus largely underestimates the observed drop in employment, which is instead overestimated by the latter model (-6.5 p.p. from late 80s to 2017). The figures for the labor share are also of interest. Although the magnitude of the decline is similar across the two scenarios (-11 pp vs -13 pp), the share of labor is lower under frictions, i.e. 39.4%, than under perfectly competitive labor market, 45%. Compared to the stylized facts discussed in the Introduction, the model is however able to rationalize the contemporaneous drop observed for the employment rate, the labor

[14]Blundell et al. (2017) suggest that liquidity constraints may also explain why many workers in the US retire at 62 or earlier.

Variables	Frictionless Labor Market			Labor Market with Frictions		
	Before	After	Change	Before	After	Change
r^*	7.44%	7.34%	-1.3%	5.49%	5.45%	-1%
Employment rate	95.02%	94.61%	-0.4%	84.06%	74.27%	-11.65%

Table 2: Steady States

share, and the equilibrium ex ante real interest rate, although most of the latter remains unexplained. This result is not surprising, for the model abstracts, on purpose, from all the changes related to demographics and productivity. The latter, however, may depend on market structure as well. As shown in Zeira (2010), monopoly power may impede growth, eventually keeping the economy stagnant, due to the downward pressure on wages, which is indeed detrimental to growth. More recently, Furman and Orszag (2017) claim that the recent productivity slowdown and inequality increase have a common cause, namely increasing market power. An interesting avenue for future research is to allow for productivity to be endogenous, and dependent on market structure.

The introduction of labor market frictions confirms that they matter: while the two models deliver a similar result in terms of impact on the interest rate, the perfectly competitive scenario largely underestimates the decline of the employment rate due to the increase of firms' market power. Consistently with the Hysteresis hypothesis, we observe that, when a shock occurs leading to lower employment, the reduced group of workers bargains a new wage so to maintain the new, lower, level of employment, which shows no tendency to return to the previous level. As a result, neglecting labor market frictions and employment dynamics, the core of the Hysteresis literature, may likely bias the evaluation of the phenomena behind Secular Stagnation.

Finally, Table 3 shows the changes of other key variables following the permanent increase in the profits share, for the economy with labor market frictions. Larger monopoly power means: lower saving and financial wealth per capita, as the demand for capital by firms is reduced; lower mobility in the labor market as the probability of finding a job, the number of vacancies, and so their aggregate cost decline. In fact, the index of labor market tightness increases. Lower long-term employment rates discourage

Variables	Before	After	Variables	Before	After
Capital (%GDP)	0.7481	0.6521	Labor Market Tightness, $\frac{Q}{V}$	0.6965	1.0171
Labor Share	0.4541	0.3940	Average Retirement Age	59.9483	58.6916

Table 3

older workers, in their 50s and 60s, who give up on the job search and retire early: a decline in older workers' activity rate and in the average retirement age occur, despite lower replacement rate for early retirees. Finally, because of the contemporaneous drop in employment and wages, the labor share permanently decreases. All these results together explain why we also observe a contemporaneous increase in the unemployment rate and in the partecipation rate, due to the rise of the share of discouraged workers.

5 Testable Implication

This section provides the empirical evidence that changes in the market structure may trigger a persistent decline both in the employment and in the natural rate.

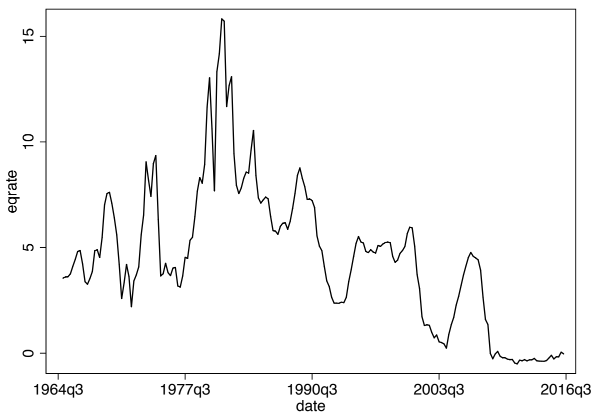


Figure 2: Natural Interest Rate for the US

I proxy the natural interest rate with the ex-ante real interest rate, defined as the equilibrium rate consistent, on average, with output at potential and stable inflation (Hamilton et al., 2015). The ex-ante real interest rate equals the nominal short-term policy rate minus expected inflation[15]. I follow the common approach in the literature of inferring expected inflation from the forecast of an autoregressive model based on the previous year inflation. The autoregressive model is estimated through 10 years rolling windows to allow for time varying coefficients. With quarterly data, the forecasting equation is a fourth-order autoregression:

$$\pi_t = c + \phi_{1,t}\pi_{t-1} + \phi_{2,t}\pi_{t-2} + \phi_{3,t}\pi_{t-3} + \phi_{4,t}\pi_{t-4} + \epsilon_t$$

The ex-ante real interest rate is thus

$$r_t = i_t - [\hat{c} + \phi_{1,t}\pi_t + \phi_{2,t}\pi_{t-1} + \phi_{3,t}\pi_{t-2} + \phi_{4,t}\pi_{t-3}] \tag{54}$$

I use quarterly data for the US for the Federal funds rate and the GDP deflator. Figure 2 shows the natural interest rate for the time period 1964q2 - 2016q3.

Before describing the structural approach and the key results, I perform a simple analysis of the correlation between the natural interest rate and the profits share, the variable I use as a proxy for the market structure. I consider corporate profits after tax (without IVA and CCAdj) as released by the U.S. Bureau of Economic Analysis. I find that the two variables are highly and negatively correlated. More in details, the coefficient for the full sample equals -0.4899. I evaluate the relation also through a peak-to-peak analysis, where peaks considered are the ones defined for the US business cycles according to NBER and data for interest rate and profits share are the averages in the period between peaks. I find a value equal to -0.2399. The correlation between the 40 quarters moving averages equals -0.6544. Finally, by dividing the sample in three main subperiods, I observe that the correlation has increased over time in absolute terms. For the first subperiod, 1964q1 to 1990q1, the correlation equals -0.0954; for the second, until 2000q1, the correlation increases to -0.3816; in the last part of the sample the correlation reaches the value -0.5630. The finding is strenghtened by the existence of a positive correlation between the natural rate and the labor share[16]. This is interesting because

[15]The assumption behind the methodology in Hamilton et al. (2015) is that "if policymakers are setting the nominal interest rate, so that on average, the output gap is zero, inflation is equal to target, and expected inflation is equal to target, then the ex ante real interest rate will equal the equilibrium interest rate as defined by the authors", Mester (2014).

[16] The correlation coefficient for the full sample is high and equal to +0.6797; for the peak-to-peak

Autor et al. (2016) and Barkai (2017), among others, have attributed the decline in the labor share exactly to the observed market changes towards a more concentrated, less competitive system.

I consider a three-variable VAR consisting of the growth of the profits share, the growth of employment (per capita) and the natural interest rate. I restrict the analysis to the sample period 1980q2 - 2015q1. Let $x_t \equiv [\Delta\pi_t, \Delta l_t, r_t^*]'$ be the stationary vector of variables where π_t, l_t and r_t^* are the (log) profits share of GDP, the (log) civilian employment (divided by population), and the natural interest rate[17]. Following Blanchard and Quah (1989), I choose an identification strategy based on long term restrictions and I focus on the market structure shock, which I interpret as motivated by either a technological or a regulatory change. The following two assumptions can be used to identify the permanent shocks:

- Only exogenous shocks to the market structure (e.g. due to regulatory or technological change) affect firms' profits share in the long run.
- Only shocks to firms' market power and exogenous shocks to the level of employment affect the latter in the long run.

These identifying restrictions can be imposed on the matrix of cumulative long run effects, $\Theta(1)$, thus implying:

$$\Theta(1) = \begin{pmatrix} \theta_{1,1} & 0 & 0 \\ \theta_{2,1} & \theta_{2,2} & 0 \\ \theta_{3,1} & \theta_{3,2} & \theta_{3,3} \end{pmatrix} \tag{55}$$

where the zeros in the first row of the above matrix mean that shocks other than an exogenous shock to the profits share do not have any influence on the latter in the long run; the zero in the second row, third column, implies that only a shock to firms market power and a labor shock affect the latter in the long run.

I focus on the effects of a permanent shock to the profits share. Being a stationary VAR, the response of all variables must be zero in the limit. Therefore Figure 3a shows

is 0.5803; for the 40 quarters moving averages equals 0.7053. Finally, the correlation is for the first subperiod, 1964q1 to 1990q1, +0.1760; for the second, +0.2644; for the third, +0.7550.

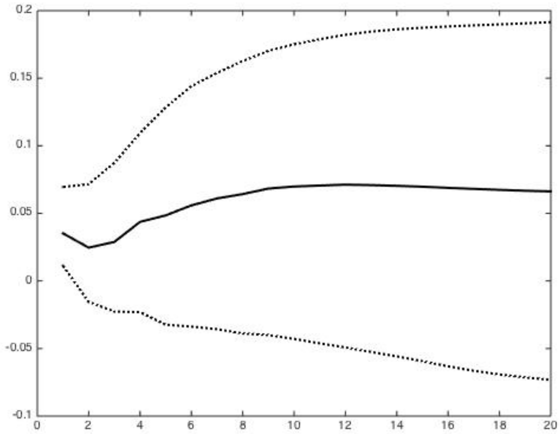
[17] I perform a Dickey-Fuller test for unit root and the Johansen tests for cointegration for π_t and l_t.

the cumulative impulse response functions. When profits share rises permanently, the employment drops on impact and stabilizes at a permanently lower level. The natural rate gradually reduces, stabilizing below the original level.

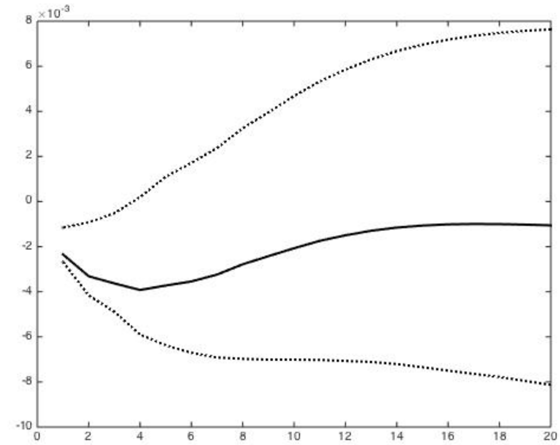
5.1 Robustness

I have conducted some robustness checks. First, I have replaced the natural interest rate with the two-sided estimates provided by Laubach and Williams (2003, 2015). Thus I have estimated the VAR based on the stationary vector $x_t \equiv [\Delta\pi_t, \Delta l_t, \Delta r_t^*]'$ where π_t, l_t and r_t^* are the (log) profits share of GDP, the (log) civilian employment (divided by population), and the Laubach and Williams natural interest rate[18].Secondly I have considered profits before taxes rather than after taxes. Finally, I have used output (per capita) instead of employment (per capita). All the results described above hold.

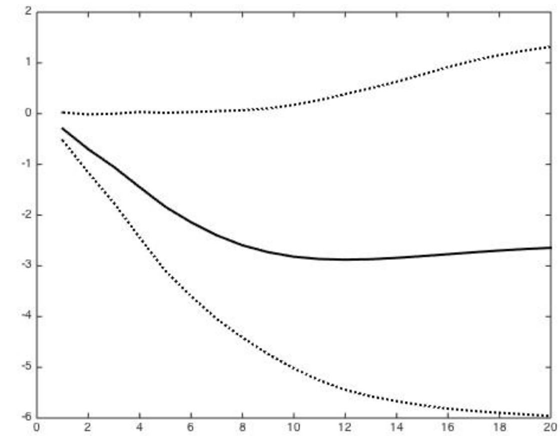
[18]By construction, r^* is integrated of order 1, see Laubach and Williams (2003).



(a) Profits share



(b) Employment



(c) Natural Interest Rate

Figure 3: Impulse response functions to a permanent shock in the profits share.

Conclusion

In this paper, I investigate the relation between market structure and Secular Stagnation, from a theoretical and an empirical standpoint. By means of an OLG setting, I focus on the effects of a change in market structure, captured by an increase in the profits share, and I show that it triggers the decline in the natural interest rate and employment. In the extended model, I introduce labor market frictions, and I show that, when accounting for them, the economy features permanently lower steady state equilibrium interest rate and employment. Moreover, labor market frictions do magnify the negative effects of the increase in the profits share, especially through employment, hence suggesting that the economy as a whole and the labor market would benefit from greater flexibility. Finally, I employ a structural VAR with long-run restrictions, to show that an increase in the profits share, as a proxy for market power, triggers a decline both in the employment level and in the natural interest rate.

Compared to the stylized facts discussed in the Introduction, the model is thus able to rationalize the contemporaneous drop observed for the employment rate, the labor share, and the equilibrium ex ante real interest rate, although most of the latter remains unexplained. This result is not surprising, for the model abstracts, on purpose, from all the changes related to demographics and productivity. The latter, however, may depend on market structure as well, hence suggesting that the observed productivity slowdown may be explained by the increase in market power. Thus, an interesting avenue for future research is to allow for productivity to be endogenous, and dependent on market structure. Moreover, two further avenues for future research open up. First, it is important to quantify the decline occurred in terms of labor market mobility and flexibility, and its impact on the equilibrium rate. Secondly, it is of interest to understand whether the observed changes of the labor market structure themselves are a consequence of an increase of monopoly power, as the rise of superstar firms may be holding labor mobility back.

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A A model with monopolistic competition

This section shows that in an economy with monopolistic competition, the decline in the natural interest rate can be explained by an increase in the markup. I consider both the cases of an exogenous and of an endogenous markup.

A.1 Exogenous markups

Consider the economy described in the simple model and consider a monopolistically competitive intermediate goods sector where producers of variety i seek to maximize nominal profits,

$$\max Z_t(i) = p_t(i)y_t(i) - W_tL_t(i) - P_tr_t^kK_t(i) \tag{56}$$

subject to a Cobb-Douglas production function in capital and labor,

$$y_t(i) = AK_t(i)^{1-\alpha}L_t(i)^{\alpha}$$

and the demand schedule, (12). The first order conditions from the problem above are

$$\frac{W_t}{p_t(i)} = \left(1 - \frac{1}{\sigma}\right)\alpha\frac{y_t(i)}{L_t(i)}$$

$$\frac{P_tr_t^k}{p_t(i)} = \left(1 - \frac{1}{\sigma}\right)(1-\alpha)\frac{y_t(i)}{K_t(i)}$$

Given the symmetry of the model, all firms charge the same price, $p(i) = p(j) = P$ and produce the same amounts, $y(i) = y(j) = Y$. Letting K_t and L_t denote the aggregate capital stock and labor supply, it follows from the first order conditions above, that

$$w_t = \frac{W_t}{P_t} = \left(1 - \frac{1}{\sigma}\right)\alpha\frac{Y_t}{L_t} \tag{57}$$

$$r_t^k = \left(1 - \frac{1}{\sigma}\right)(1-\alpha)\frac{Y_t}{K_t} \tag{58}$$

By the firms' demand for labor and capital, marginal products of production inputs equal real marginal costs plus a markup. The presence of market power generates a wedge between the marginal product and the cost, and both the real wage and the return on capital are lower than their counterparts under perfect competition[19]. I define

$$\mu \equiv \frac{\sigma}{\sigma - 1}$$

[19]Under perfect competition, the solution is $w_t^* = \alpha\frac{Y_t}{L_t}$ and $r_t^{k*} = (1-\alpha)\frac{Y_t}{L_t}$.

as the measure of monopoly/market power. Equilibrium prices thus are not exogenous but are determined endogenously and depending on market power. The latter is a decreasing function of the elasticity of substitutability across varieties, σ. As $\sigma \to \infty$, the economy tends to the perfect competition benchmark.

It is straightforward to verify that the equilibrium conditions, Eqs. (57) and (58), coincide with Eqs. (14) and (15) where z is replaced by $\frac{1}{\sigma}$. Thus, the analysis proceeds in a similar fashion. The increase in market power comes from an increase in the markup triggered by a decrease in the elasticity of substitution, σ. In particular, consider the parameter as listed in Table 4, Column 2. A shock occurs and the elasticity of substitution drops from 10 to 2. The effects on the equilibrium are represented in Figure 1. The intuition of the underlying dynamics follows from what discussed at the end of the previous Section.

A.2 Endogenous markups

In this section I assume that the markup depends on the number of firms which is endogenously determined in equilibrium and depends on the level of sunk costs that each firm has to bear. The task of this section is to construct an equilibrium with free entry and free exit where all firms face the same production technology and to characterize the effects of an increase in sunk costs.

This extension follows Galì (1995), Peretto (1996), Bilbiee et al. (2012) and Cacciatore et al. (2015) who study the implications for macroeconomic fluctuations with an endogenous determination of the number of firms. Sunk costs are needed to bound and determine the equilibrium number of firms. The way sunk costs are introduced, whether they are entry or production sunk costs, is crucial. If sunk costs only burden production as in Peretto (1996), then entry is frictionless and the number of firms is a jumping variable which is free to adjust at its equilibrium value at any point in time. If sunk costs burden entry as in Bilbiee et al. (2012) and Cacciatore et al. (2015), then profits are allowed to vary and the number of firm is a state variable. In the latter scenario it makes sense to characterize the short-term as described by a fixed number of firms, while in the former there is no such difference. In this sense, the paper relates to the literature on the effects of structural reforms that aim to reduce markups by promoting competition. Blanchard and Giavazzi (20013), Bayoumi et al. (2004), Eggertsson et al. (2013), Fernández-Villaverde et al. (2014), and Gerali et a. (2015) show the beneficial effects of structural reforms in different contexts. In particular, Gerali et a. (2015) discuss the key role played by physical capital in magnifying the wealth effect. Eggertsson et al. (2013) show that although structural reforms have a long-term positive effect on output, they do have contractionary effects in the short-run. However, there are two major differences with Eggertsson et al. (2013) which potentially may lead to different results: the presence of capital and the endogeneity of the number of firms. First of all, accounting for firms' incentives to operate, though in a frictionless entry economy, eliminates the short-term distortions. Moreover, as postulated in Fernández-Villaverde (2014), the introduction of capital turns out to be the essential channel for the transmission of the effects of structural changes.

Following Galì (1995), I assume that the elasticity of substitution and markup are endogenous, and depend on the size of the market for intermediate goods. Specifically, σ is a function of n, the number of intermediate goods, and has the following properties:

$$\frac{\partial \sigma(n)}{\partial n} = \sigma'(n) > 0 \qquad \lim_{n \to 0} \sigma(n) = \bar{\sigma} > 1 \qquad \lim_{n \to \infty} \sigma(n) \to \infty$$

Final good producers

Final good producers seek to maximize profits as in Eq. (11) and they adopt the following technology

$$Y = [n^{-(1-\frac{1}{\mu(n)})} \int_0^n y(i)^{\frac{1}{\mu(n)}} di]^{\mu(n)}$$

where $y(i)$ is the quantity of intermediate goods $i \ \epsilon \ [0, n]$ and $\mu : R^+ \to R^+$ is a continuously differentiable function with the following properties:

$$\frac{\partial \mu(n)}{\partial n} = \mu'(n) < 0 \qquad \lim_{n \to 0} \mu(n) = \bar{\mu} > 1 \qquad \lim_{n \to \infty} \mu(n) = 1$$

The above properties follow from the assumption about the elasticity of substitution among goods, $\sigma(n) = \frac{\mu(n)}{\mu(n)-1}$.

The solution to the final good producers' problem gives the following demand schedule for the variety i:

$$y_t(i) = \frac{Y_t}{n_t}\left(\frac{P_t}{p_t(i)}\right)^{\sigma(n_t)} \tag{59}$$

where the aggregate price index, P, is $P \equiv \left[\frac{1}{n}\int_0^n p(i)^{1-\sigma(n)}di\right]^{\frac{1}{1-\sigma(n)}}$.

Intermediate good producers

Each firm i seeks to maximize profits, Eq. (56), subject to the demand schedule, Eq. (59), and a production function which accounts for sunk costs:

$$y_t(i) = AK_t(i)^{1-\alpha}L_t(i)^{\alpha} - \Omega$$

where Ω represents exogenous sunk costs, meant as the minimum level of R&D expenses required for production. I follow Peretto (1996) and I assume frictionless entry so that the number of firms is a jumping variable which is free to adjust at its equilibrium value at any point in time such that profits are zero.

Concerning the natural interpretation for sunk costs, they are generally referred to as R&D expenditures[20]. Autor et al. (2016) and Kahle and Stilz (2016) provide evidence that there has been an increase in R&D expenditures in the recent decades. Moreover, Autor et al. (2016) provide the empirical evidence that technological change has made markets increasingly concentrated so that the firms with higher productivity increasingly capture a larger share of the market. They find that the industries that became more concentrated were also the industries in which productivity increased the most. In the extended theoretical model, I show that the increase in sunk costs has contractionary effects by triggering a decrease in the number of active firms and thus an increase in the markup.

By optimality follows:

$$K_t(i): \quad \left(1 - \frac{1}{\sigma(n_t)}\right)\left(\frac{n_t}{Y}\right)^{-\frac{1}{\sigma(n_t)}} P_t y_t(i)^{-\frac{1}{\sigma(n_t)}}(1-\alpha)AK_t^{-\alpha}(i)L_t(i)^{\alpha} = P_t r_t^k$$

$$L_t(i): \quad \left(1 - \frac{1}{\sigma(n_t)}\right)\left(\frac{n_t}{Y}\right)^{-\frac{1}{\sigma(n_t)}} P_t y_t(i)^{-\frac{1}{\sigma(n_t)}}\alpha AK_t^{1-\alpha}(i)L_t(i)^{\alpha-1} = W_t$$

[20] One of the reasons for this interpretation lies on the accounting rules. Both under the IAS 38 and the US-GAAP, R&D expenses, unlike capital expenditures, are not capitalized.

Given the symmetry of the model, all firms face the same marginal costs, hence equilibrium prices and quantities are identical across firms. Equalities of prices, by Eq. (59), implies that $y(i) = \frac{Y}{n}$, and so, $K(i) = \frac{K}{n}$, and $L(i) = \frac{L}{n}$. Hence, the aggregate production function in equilibrium can be written as follows:

$$Y_t = AK_t^{1-\alpha}L_t^{\alpha} - n_t\Omega \tag{60}$$

and first order conditions as

$$w_t = \left(1 - \frac{1}{\sigma(n_t)}\right)\alpha\frac{(Y_t + n_t\Omega)}{L_t} \tag{61}$$

$$r_t^k = \left(1 - \frac{1}{\sigma(n_t)}\right)(1-\alpha)\frac{(Y_t + n_t\Omega)}{K_t} \tag{62}$$

where I have used the production function and the fact that $W_t = w_tP_t$.

Moreover, in equilibrium the number of firms is such that the zero-profit conditions is always satisfied. Analitically, real profits are defined as follows:

$$\begin{aligned} Z_t = Y_t - w_tL_t - r_t^kK_t = \\ Y_t - \left(1 - \frac{1}{\sigma(n_t)}\right)\alpha\frac{Y_t + n_t\Omega}{L_t}L_t - \left(1 - \frac{1}{\sigma(n_t)}\right)(1-\alpha)\frac{Y_t + n_t\Omega}{K_t}K_t = \\ \frac{\left(\mu(n_t) - 1\right)Y_t - n_t\Omega}{\mu(n_t)} \end{aligned} \tag{63}$$

where I have used Eqs. (61), (62) and the definition for the markup, μ. By Eq. (63) profits depend on the number of firms, level of sunk costs and aggregate demand.

A.2.1 Steady State

I focus on the steady state equilibria. As in the baseline model, there are two scenarios, depending on whether the gross rate of inflation is above or below 1.

Case $\Pi > 1$

$$r^k = \left(1 - \frac{(1-\delta)}{1+r}\right)$$
$$r^k = \left(1 - \frac{1}{\sigma(n)}\right)(1-\alpha)\frac{AK^{1-\alpha}\bar{L}^{\alpha}}{K}$$
$$Y = AK^{1-\alpha}\bar{L}^{\alpha} - n\Omega$$
$$Y = D + \frac{1+\beta}{\beta}\frac{1+g}{1+r}D + K\left(1 + \frac{(1-\delta)}{\beta(1+r)}\right)$$

with $1 + r = \Pi^{\phi_\pi - 1}$ by the Taylor rule.

Case $\Pi < 1$

$$L = \left(\frac{1 - \frac{\gamma}{\Pi}}{1-\gamma}\right)^{\frac{1}{1-\alpha}}\bar{L}$$
$$r^k = \left(1 - \Pi(1-\delta)\right)$$
$$r^k = \left(1 - \frac{1}{\sigma(n)}\right)(1-\alpha)\frac{AK^{1-\alpha}L^{\alpha}}{K}$$
$$Y = AK^{1-\alpha}L^{\alpha} - n\Omega$$
$$Y = D + \frac{1+\beta}{\beta}(1+g)\Pi D + K\left(1 + \frac{\Pi}{\beta}(1-\delta)\right)$$

Finally, the zero profits condition then implies that the equilibrium number of firms, n^*, satisfies the following condition:

$$n^*: \frac{Y}{n} = \frac{\Omega}{\mu(n) - 1} \tag{64}$$

Assumption 1 I assume

$$\sigma(n) = \sigma n$$

where $\sigma > 0$. The latter implies $\mu(n) = \frac{\sigma n}{\sigma n - 1}$.

By the zero profits condition, then

$$n^* = \frac{1 + \sqrt{1 + \frac{4\sigma Y}{\Omega}}}{2\sigma} \tag{65}$$

The equilibrium number of firms, n^*, is a positive function of output and a negative function of sunk costs, Ω. Moreover, by combining the zero profit condition with the aggregate production function[21] and Eq. (62), I obtain the equilibrium rental rate of capital, r^k:

$$r^k = (1-\alpha)\frac{AK^{1-\alpha}L^{\alpha}}{K} - (1-\alpha)\frac{\sqrt{AK^{1-\alpha}L^{\alpha}}}{K}\sqrt{\frac{\Omega}{\sigma}} \tag{66}$$

As the above equation makes clear, the final effect of sunk costs is negative. Indeed, by Eq. (62), sunk costs have a direct and an indirect effect on the rental rate of capital. The direct effect is positive, since sunk costs raise the marginal productivity of capital. The indirect one works through the reduction in the number of active firms. Sunk costs in fact reduce the number of firms through Eq. (65), which in turn increases the markup and lowers the return. By Eq. (66), it is clear that the indirect, negative effect prevails over the direct, positive one.

The system of equilibrium conditions, as it is, is not easily manageable. In order to obtain a graphical representation of the equilibrium and to perform the comparative statics that I am interested in, I define $\hat{x}_t = \frac{x_t}{n_t}$ as the generic variable x_t expressed in terms of number of firms in the market, n_t, and I rewrite the equilibrium conditions as follows:

$$r^k = \left(1 - \frac{(1-\delta)}{1+r}\right) \tag{67}$$

$$r^k = \left(1 - \frac{1}{\sigma n}\right)(1-\alpha)\frac{\hat{Y}+\Omega}{\hat{K}} \tag{68}$$

$$\hat{Y} = A\hat{K}^{1-\alpha}\hat{L}^{\alpha} - \Omega \tag{69}$$

$$\hat{Y} = \frac{n_{-1}}{n}\hat{D} + \frac{1+\beta}{\beta}\frac{1+g}{1+r}\hat{D} + \hat{K}\left(1 + \frac{(1-\delta)}{\beta(1+r)}\right) \tag{70}$$

$$n = \frac{\hat{Y}+\Omega}{\sigma\Omega} \tag{71}$$

where $1+r = \Pi^{\phi_\pi - 1}$ and $\hat{L} = \bar{L}$ if $\Pi > 1$, while $1+r = \Pi^{-1}$ and $\hat{L} = \left(\frac{1-\frac{\gamma}{\Pi}}{1-\gamma}\right)^{\frac{1}{1-\alpha}}\bar{L}$ if $\Pi < 1$.

The equilibrium conditions are in fact now easily comparable to the ones obtained

[21]By combining the zero profit condition with the production function, it follows that n^* can be written as $n^* = \sqrt{\frac{AK^{1-\alpha}L^{\alpha}}{\sigma\Omega}}$.

for the baseline model and the key channels through which the market structure affects the equilibrium allocation are easily identifiable. The number of firms enters in Eq. (68) through the term $\left(1-\frac{1}{\sigma n}\right)$ which measures the inverse of the effective markup which is decreasing in the number of firms. Moreover, when shocks have occurred, such that the equilibrium number of firms has changed and $n_{-1} \neq n$, a change in the number of firms has a further effect on aggregate demand, Eq. (70), by relaxing or tightening the borrowing constraint through its effect on the equilibrium interest rate.

As for the solution of the baseline model, I substitute out for K, L, r^K, r and n within (69) and (70) to get the AS and AD schedules as functions of the two endogenous variables, $\hat{Y}$ and Π. In particular, by combining (67) and (68), I get the equilibrium level of capital, $\hat{K}$:

$$\hat{K} = \left(1 - \frac{1}{\sigma n}\right)(1 - \alpha)(1 - \frac{(1-\delta)}{1+r})^{-1}(\hat{Y} + \Omega) = \frac{(1-\alpha)(1+r)}{\delta + r}\hat{Y}$$

where I have used (71) for the second equality. Compare the first equality with the counterpart for the baseline model, (21). Two novel elements emerge, that is the equilibrium level of capital depends on sunk costs and on the number of firms. By the second equality, after substituting out for the number of firms, Eq. (71), I get the equibrium level of capital as a function solely of the two endogenous variables.

A.2.2 A change in market structure

Following the analysis in the baseline model, I focus on the effect of a change in the market structure. Employing an endogenous markup model helps me track the behaviour of firms and the number of active firms. The latter is determined in equilibrium and depends on the cost structure. As discussed in the Introduction, the empirical evidence shows indeed that the recent decades have been characterized by deep changes in the cost structure, and by a substantial increase in sunk costs such as R&D expenses, compliance costs. Therefore, I consider the case of an increase in sunk costs, from $\Omega = 1.35$ to $\Omega = 1.74$, which delivers a neutral interest rate equal to -0.0036. Figure 4 shows the effects on the equilibrium allocation, given the parametrization described in Table 4, Column 2. The economy goes from Full Employment, point A, to Secular Stagnation, point B and the equilibrium number of firms, as defined by (65), declines by 0.2%.

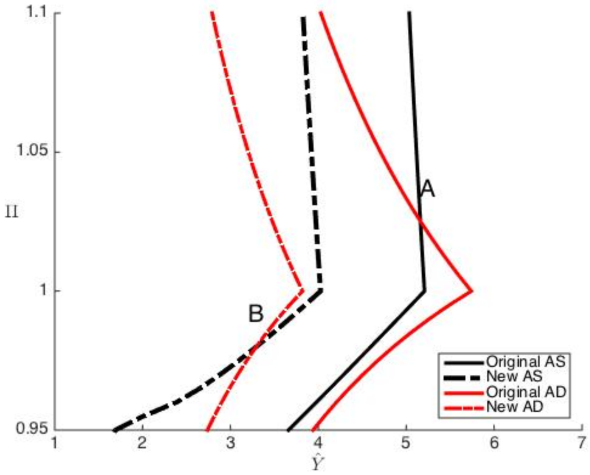


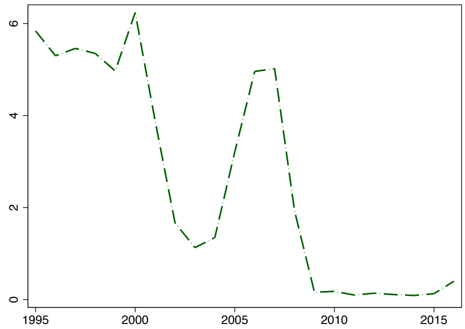
Figure 4: Effects of a change in market structure in the extended model with monopolistic competition and endogenous output. The solid lines represent the AS and the AD schedules before the shock, and the original steady state is in A. I consider the case of an increase in the markup, either triggered by an exogenous reduction in the elasticity of substitution across goods or as a consequence of an increase in sunk costs and a decrease in the number of firms. Both the AS and the AD schedules move leftwards (the dashed lines). The economy moves to the new steady state, B.

The rationale builds on the one discussed for the baseline model. On the aggregate supply side, two forces are at work. First of all, the increase in sunk costs depresses profits and production leading to a decrease in the number of firms, which in turn widens the markup, and depresses potential output. The AS schedule, and consequently the AD schedule, both shift leftwards. Moreover, as in the baseline model, an aggregate demand externality worsens the consequences of the negative shock as the zero lower bound binds and the economy enters Secular Stagnation. Differently from the baseline model, the extended model shows that the decline in the number of firms has also a positive effect on aggregate demand, since $\frac{n_{-1}}{n} > 1$. The rationale is that since the reduction in the number of firms triggers a reduction in the equilibrium interest rate, the latter leads to a slight relaxation of the borrowing limit which stimulates spending, though not enough to compensate the negative effects.

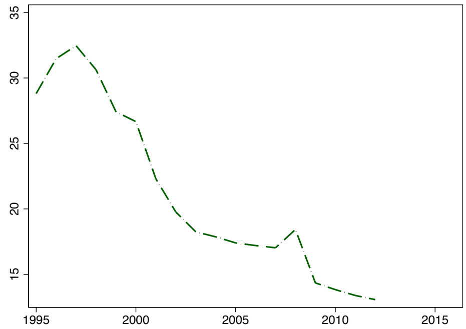
Description	Parameter	(1) Value	(2) Value	(3) Value
Labor Supply	$\bar{L}$	1	1	1
TFP	A	1.2	1.2	3.4
Discount factor	β	0.99	0.99	1
Taylor coefficient for π	ϕ_π	1.5	1.5	1.5
Labor share	α	0.9	0.9	0.5
Profits' Share	z	0.1	N.E.	N.E.
Elasticity	σ	N.E.	10	0.001
Wage adjustment	γ	0.4	0.4	0.6
Inflation Target	Π^*	1	1	1
Borrowing Limit	D	0.285	0.285	0.2
Depreciation	δ	0.6	0.6	0.6
Growth rate	g	0.001	0.001	0.05
Sunk Costs	Ω	N.E.	N.E.	1.35

Table 4: Columns (1) refers to the simple model with monopoly. Column (2) and (3) refer to the model with monopolistic competition and, respectively, exogenous and endogenous markup in Appendix A.

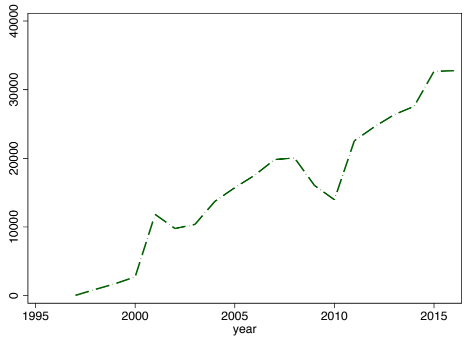
B Figures



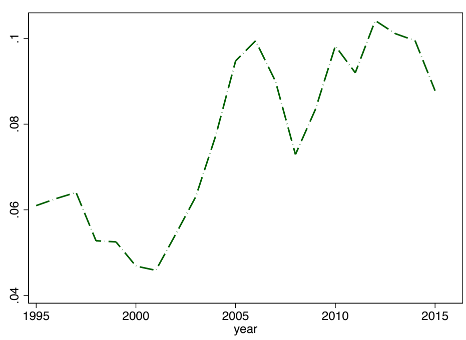
(a) 3-Month Treasury Bill.



(b) Number of listed companies.



(c) Number of M&As, total deals. Zephyr.



(d) Corporate Profits After Tax (% GDP).

Figure 5: Stylized Facts.

Industry	1997	2007	2012	Change 1997-2012
Transportation and Warehousing	30.7	42.7	42.1	+37 %
Professional, Scientific, and Technical Services	16.2	18.3	18.8	+16 %
Retail Trade	25.7	33.3	36.9	+35.9%
Arts, Entertainment and Recreation	21.8	19.5	19.6	-10%
Finance and Insurance	38.6	46.0	48.5	+25.6%
Administrative/Support	22.0	23.0	23.7	+7.7%
Wholesale Trade	20.3	24.9	27.6	+36%
Healthcare and Assistance	18.8	15.1	17.2	+8.5%
Real Estate Rental and Leasing	19.5	26.1	24.9	+27.7%
Accomodation and Food Services	21.1	23.7	21.2	+0.05%
Utilities	64.5	70.1	69.1	+7%
Other Services, Non Public Admin	12.8	11.3	10.9	-14.8%
Educational Services	19.6	22.3	22.7	+15.8%

Table 5: Change in Market Concentration by Sector. Market concentration is measured as the share of sales for the 50 largest firms. Source: Economic Census.

(a) Nonfarm Business Sector: Labor Share.

Source: U.S. Bureau of Labor Statistics

(b) Total capital expenditure (%Total Assets).

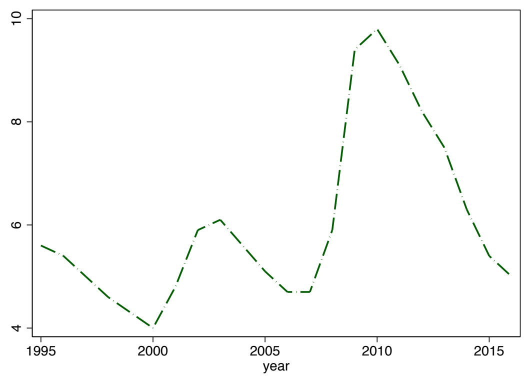
Source: Financial Accounts of the US

(c) Gross Fixed Investment (%Total Assets).

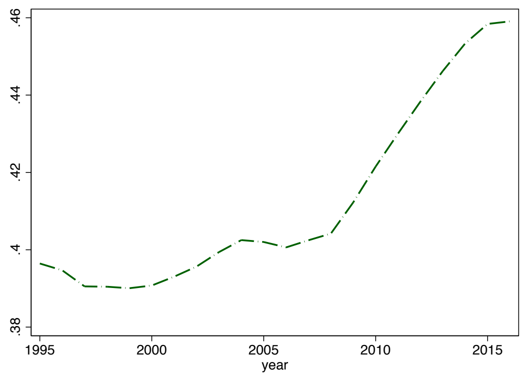
Source: Financial Accounts of the US

(d) Employment Rate: Aged 15-64.

All Persons for the United States



(e) Unemployment rate.



(f) Not in labor force (%).

Figure 6: Stylized Facts.