Chapter 2: Economic Growth Under the Effect of Market Power[1]

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One of the conclusions of Chapter 1 is that the prediction of constant relative shares, made by neoclassical competitive growth theory, fails to hold in an economy with fluctuating monopoly power, even if the aggregate production function is Cobb-Douglas. In this chapter I expand the scope of the analysis to explore other conclusions of the traditional theory that are altered by the presence of market power. The ultimate aim is to clarify the macroeconomic implications of fluctuating market power. To do that I formulate a more specific model of growth that preserves the basic elements of neoclassical growth theory but allows for varying monopoly power, formulated as an endogenous state variable. I focus on studying general theoretical effects of changing market power on the dynamics of growth, rather than engage in precise calibrations, but I follow existing empirical estimates where they are available.

The model I use is a version of the Dixit-Stiglitz model in which firms have pricing power. This is a standard model, used by others to address diverse problems. For example, Hornstein (1993) and Cooper (1993) use it (with increasing returns) to assess the propagation of productivity shocks. Karabarbounis and Neiman (2014) use it to explain the decline of labor share due to capital/labor substitution motivated by the decline in the relative prices of capital to labor. Barkai (2016a) uses a similar model to deduce the mark-up and aggregate profits.

As to my general approach, in Section 1.7 I have shown that income and wealth inequality can be studied without a complete general equilibrium model (see also Solow (1960)). Now I want to study other aggregate implications of changing market power, and for that one needs a dynamic general equilibrium treatment. To avoid too high a level of abstraction, I will then work with the *simplest* possible assumptions, but explain why the results remain valid even under more general conditions. The model has M firms each producing a distinct product so that the sum of the market values of the M output produced by the firms is GNP. Any two products are differentiated by the firms's unique and proprietary technology and trademark, but they may exhibit some substitution. The firm maximizes profits by selecting its price, given prices of the others, hence I study Nash equilibrium in prices. There is no free entry but if M is large and all M goods are very close substitutes, the model become an approximate for monopolistic competition. These distinctions are important, but are not relevant to the central questions I study.

In much of this book, I use models with identical consumers (hence with a representative consumer) and a finite number of firms producing differentiated products. Here I assume a single consumption good which is a composition of M different intermediate goods, each being produced by a firm with market power. Some product differentiation can also arise in the composition of the consumption aggregate, which I take to have a specific form, with a constant but time varying elasticity of substitution. I consider only symmetric general equilibria, and the focus on symmetry is motivated by a desire for simplicity. I want to keep the exposition as simple as possible, yet be able to draw general conclusions about the effect of market power on macroeconomic aggregates.

2.1 A general equilibrium model of growth

There are a large number of identical consumer-households with utility over consumption and labor, who optimize dynamically over time with a utility function

$$(2.1) \qquad U_t = \sum_{\tau=t}^{\infty} \beta^{(\tau-t)} u(C_\tau, L_\tau).$$

Consumption follows a Dixit and Stiglitz (1977) framework but with M firms producing differentiated intermediate products. M is constant because there is no free entry. Since innovations generate new firms with new technology who may replace old firms, one may think of the firms as dynasties where the name may change over time. As discussed earlier, the firms that produce them have proprietary technologies that differentiate these commodities. These commodities are used by households and firms to produce final consumption or investment goods, which are CES composites of the intermediate goods.

$$(2.2) \qquad Y_t \equiv C_t + I_t = \Omega\left[\sum_{j=1}^{M} \vartheta_j (Y_{it})^{\frac{\theta_t - 1}{\theta_t}}\right]^{\frac{\theta_t}{\theta_t - 1}}.$$

Y_{it} is the amount of intermediate commodity i, measured in units of that good, used in producing output Y_t, consumption C_t and investment I_t, which are *all measured in units of consumption good.* θ_t is the elasticity of substitution, with $\theta_t = \infty$ being the case of perfect competition but I consider only $\infty > \theta_t > 1$ that permits profit maximization. I allow this variable to fluctuate over time. These fluctuations reflect changes in product differentiation and changes in monopoly power of firms, which are the central concern of this book. An alternative formulation, which better describes market power, defined by (1.6) in terms of the markup used

$$Y_t = \left[\sum_{j=1}^{M} \vartheta_j (Y_{jt})^{(\frac{1}{\mathcal{P}_t})}\right]^{\mathcal{P}_t} \quad , \quad \mathcal{P}_t = \frac{\theta_t}{\theta_t - 1} \quad , \quad \mathcal{P}_t \geq 1,$$

where the competitive economy is defined by $\mathcal{P}_t = 1$. The formulation (2.2) is more common.

I introduce the index ϑ_j in the CES aggregator to express differences in quality and efficacy of intermediate goods, and I study the impact of R&D in Chapter 7, by allowing ϑ_{jt} to depend on firms' R&D choice. In this chapter I formulate the model with ϑ_j varying across firms so that the basic model formulation need not be repeated later. However, here I will ultimately keep ϑ_{jt} constant over time. Each intermediate good is produced by a firm that has monopoly right to produce that commodity, and I have explained in Chapter 1 that the model with fixed number of commodities and with changing quality is very general.

The model gives rise to monopoly pricing by producers of intermediate goods and I need to clarify my assumptions about capital ownerships. I study long term processes and the unit of time in the analysis is a year. With such long time horizon, I can assume that capital and labor are freely mobile, hired in free markets and paid the competitive wage rate and rental rates (W_t, R_t). Hence, the treatment of capital and labor are symmetric, and households own[2] the capital they rent to firms. Aggregate capital grows in accord with $K_{t+1} = (1-\delta)K_t + I_t$ (δ being the depreciation rate), and aggregate labor available is exogenous and fixed at the level of 1. In profit calculations firms take into account the market costs of capital and labor as given and maximize profits at any date by choosing the quantity of those inputs to hire from households. The key assumption made is, then, that consumers, households or capital owners do not form coalitions to break the pricing power of firms. Under such assumptions *capital owners and stock holders perform different functions.* Firms' ownership shares are traded in open markets, and profits are distributed to stock holders as dividends only after capital and labor are paid their incomes in accord with the market prices at which they are hired. An alternative model, which is not considered here, could have a class of entrepreneurs who own all the shares but who do not work, while households do not own shares. Such entrepreneurs may own capital, therefore their consumption and savings are financed by dividends paid by their shares and rental from capital ownership, if they own any.

To derive demand functions, I first address the issue of measurement units. Starting with Dixit and Stiglitz (1977), it is common to use labor as a numéraire. Since I integrate the model with a neoclassical production structure, I prefer to use consumption as a reference. I therefore first introduce an abstract unit of account with which to write the budget constraints. Values in consumption units are then deduced from prices relative to the price of the consumption good.

Since the utility function is increasing in consumption, one can derive the implied demand functions for intermediate goods with prices P_{jt} from the following optimization procedure:

$$\text{(2.3)} \quad \text{Maximize } Y_t = \left[\sum_{j=1}^{M} \vartheta_j (Y_{jt})^{\frac{\theta_t - 1}{\theta_t}}\right]^{\frac{\theta_t}{\theta_t - 1}} \text{ subject to the cost of } P_t Y_t = \sum_{j=1}^{M} P_{jt} Y_{jt}.$$

The implied demand functions depend upon expenditures $P_t Y_t$. The first order conditions are

$$\text{(2.4)} \quad P_{jt}\lambda_t = Y_t^{\frac{1}{\theta_t}} \vartheta_j (Y_{jt})^{-\frac{1}{\theta_t}} \;\Rightarrow\; \left(\frac{\vartheta_i P_{jt}}{\vartheta_j P_{it}}\right)^{-\theta_t} = \left(\frac{Y_{jt}}{Y_{it}}\right) \;\Rightarrow\; P_{jt} Y_{jt} = Y_{it}\left(\frac{P_{it}}{\vartheta_i}\right)^{\theta_t}\left(\frac{P_{jt}}{\vartheta_j}\right)^{1-\theta_t}\vartheta_j \qquad \text{all i and j.}$$

Add up the last expression, using the right hand side of (2.3)

$$P_t Y_t = \sum_{j=1}^{M} P_{jt} Y_{jt} = Y_{it}(P_{it}/\vartheta_i)^{\theta_t} \sum_{j=1}^{M} (P_{jt}/\vartheta_j)^{1-\theta_t}\vartheta_j \;\Rightarrow\; Y_{it} = \frac{(P_{it}/\vartheta_i)^{-\theta_t}}{\sum_{j=1}^{M} \vartheta_j (P_{jt}/\vartheta_j)^{1-\theta_t}} P_t Y_t .$$

Define the price

[2] This assumption is made for simplicity since, as I shortly explain, it implies the firm needs to solve only a static optimization problem, while the households do all dynamic optimizations, and take the risk of the actual return on capital they receive, which is determined one period after they make the saving decision. If the firm owns the capital it must also perform a dynamic optimization.

(2.5) $$P_t = [\sum_{j=1}^{M} \vartheta_j (\frac{P_{jt}}{\vartheta_j})^{1-\theta_t}]^{\frac{1}{1-\theta_t}}$$

and the demand functions

(2.6) $$Y_{jt}^{C} = \frac{(P_{jt}/\vartheta_j)^{-\theta_t}}{(P_t)^{-\theta_t}} C_t \quad , \qquad Y_{jt}^{I} = \frac{(P_{jt}/\vartheta_j)^{-\theta_t}}{(P_t)^{-\theta_t}} I_t \quad , \; Y_{jt} = \frac{(P_{jt}/\vartheta_j)^{-\theta_t}}{(P_t)^{-\theta_t}} Y_t .$$

This amounts to assuming that capital is measured in units of consumption and a unit of capital is exchanges for a unit of investment at the rate of 1 for 1 hence there is no change in the relative price of consumption and capital goods.

The price P_t is the cost of a unit of consumption or investment at the optimal mix of intermediate goods (see Brakman and Heijdra (2004), Chapter 1). So far I used only the right hand side of (2.3). I also have the definition of GNP in consumption units

$$\sum_{j=1}^{M} (\frac{P_{jt}}{P_t}) Y_{jt} = \sum_{j=1}^{M} \vartheta_j (\frac{P_{jt}}{\vartheta_j})^{1-\theta_t} (\frac{1}{P_t})^{1-\theta_t} Y_t .$$

I will later assume there are production functions for intermediate goods, therefore

$$Y_t = \sum_{j=1}^{M} (\frac{P_{jt}}{P_t}) Y_{jt} \equiv \sum_{j=1}^{M} (\frac{P_{jt}}{P_t}) \zeta_t \Omega \Psi_j (K_{jt})^{\alpha} (A_t N_{jt})^{(1-\alpha)}$$

To evaluate λ_t, multiply(2.4) by Y_{jt} and add to deduce

$$Y_t P_t \lambda_t = \sum_{j=1}^{M} Y_{jt} P_{jt} \lambda_t = Y_t^{\frac{1}{\theta_t}} \sum_{j=1}^{M} \vartheta_j (Y_{jt})^{\frac{\theta_t - 1}{\theta_t}} = Y_t^{\frac{1}{\theta_t}} Y_t^{\frac{\theta_t - 1}{\theta_t}} \quad \Rightarrow \quad \lambda_t = \frac{1}{P_t} .$$

2.2 Optimization by intermediate goods' producers

Each firm j has a production function of the form

$$Y_{jt} = \zeta_t \Omega \Psi_j (K_{jt})^{\alpha} (A_t L_{jt})^{(1-\alpha)}$$

where ζ_t is a process of Markov productivity shocks with mean 1 and $A_t = g_0 g^{t}$ is a common deterministic productivity factor growing at a constant rate g. The parameter Ω is introduced to adjust the units of intermediate goods so that the steady state relative price of intermediate goods to consumption is 1.

The date t profit function is

$$\Pi_t^j = P_{jt} Y_{jt} - P_t W_t L_{jt} - P_t R_t K_{jt},$$

where factor costs (W_t, R_t) are in units of consumption or "real" terms. I study the Nash equilibrium in prices, hence, producers take aggregate income and price P_t as given and choose their own prices and quantity of labor and capital employed to maximize profits at each date:

(2.7a) $$\text{Max}_{P_{jt},N_{jt},K_{jt}}\left[P_{jt}Y_{jt}-P_tW_tL_{jt}-P_tR_tK_{jt}+\lambda_{jt}[\zeta_t\Omega\Psi_jK_{jt}^{\alpha}(A_tL_{jt})^{1-\alpha}-Y_{jt}]\right],\ Y_{jt}=(\frac{P_{jt}}{\vartheta_jP_t})^{-\theta_t}(C_t+I_t)$$

The first order conditions are then

(2.7b) $$(\theta-1)(\frac{P_{jt}}{\vartheta_jP_t})^{-\theta_t}(C_t+I_t)=\lambda_{jt}\theta_t(\frac{P_{jt}}{\vartheta_jP_t})^{-\theta_t}(C_t+I_t)P_{jt}^{-1}\ \Rightarrow\ \lambda_{jt}=P_{jt}\frac{(\theta_t-1)}{\theta_t}\ \text{all } j$$

(2.7c) $$W_t=\frac{P_{jt}}{P_t}\frac{(\theta_t-1)}{\theta_t}(1-\alpha)\Omega\Psi_j[\zeta_tA_t^{1-\alpha}](K_{jt})^{\alpha}(L_{jt})^{-\alpha}=\frac{P_{jt}}{P_t}\frac{(\theta_t-1)}{\theta_t}\frac{\partial Y_{jt}}{\partial L_{jt}}.$$

(2.7d) $$R_t=\frac{P_{jt}}{P_t}\frac{(\theta_t-1)}{\theta_t}\alpha\Omega\Psi_j[\zeta_tA_t^{1-\alpha}](K_{jt})^{\alpha-1}(L_{jt})^{1-\alpha}=\frac{P_{jt}}{P_t}\frac{(\theta_t-1)}{\theta_t}\frac{\partial Y_{jt}}{\partial K_{jt}}.$$

Variations in the quality parameters ϑ_j does not impact (2.7c)-(2.7d). Since all income distribution results depend upon (2.7c)-(2.7d), these distributions are invariant to the heterogeneity assumptions. Based on Section 1.7, one could have expected this conclusion since (1.4) was developed in full generality. Accordingly, by (2.7c)-(2.7d) and by the definition of output, it follows that

$$Y_t=\frac{\theta_t}{\theta_t-1}[R_t\sum_{j=1}^{M}K_{jt}+W_t\sum_{j=1}^{M}L_{jt}]=\frac{\theta_t}{\theta_t-1}[R_tK_t+W_tL_t],$$

which implies that the distribution of income is

	Labor income	$W_tL_t=(1-\alpha)\frac{\theta_t-1}{\theta_t}Y_t$
(2.8)	Capital rental income	$R_tK_t=\alpha\frac{\theta_t-1}{\theta_t}Y_t$
	Monopoly profits	$=\frac{1}{\theta_t}Y_t.$

(2.8) is the same as (1.4). The share of monopoly profits is $1/\theta_t$.

A similar functional distribution of income takes place at the level of each firm, so that the profits of firm j are then defined by

$$\text{Monopoly profits of firm } j=\Pi_{jt}=\frac{1}{\theta_t}Y_{jt}\frac{P_{jt}}{P_t}.$$

2.3 Aggregation and the key role of relative prices in measured productivity

I now proceed formally to deduce the aggregation of this market economy. To that end I start with the following proposition, taking advantage of the symmetry of the producers:

Proposition 2.1: In equilibrium

(i) Relative prices satisfy $\frac{P_{jt}}{P_t}\Psi_j = \varphi_t$ for all j where

(2.9a) $$\varphi_t = [\sum_{j=1}^{M} \vartheta_j^{\theta_t}]^{\frac{1}{\theta_t - 1}}$$

(ii) Equilibrium quantities act in accordance with an aggregate production function and

(2.9b) $$Y_t = \varphi_t \zeta_t \Omega (K_t)^{\alpha} (A_t L_t)^{(1-\alpha)}.$$

Proof: (i) (2.7c)-(2.7d) imply

$$\frac{W_t}{R_t} = \frac{(1-\alpha)}{\alpha}(\frac{K_{jt}}{L_{jt}}) \quad \text{for all j}$$

hence (K_{jt}/N_{jt}) is independent of j. By (2.7c),

$$\frac{P_{jt}}{P_t}\Psi_j = \frac{W_t}{(\frac{\theta_t - 1}{\theta_t})(1-\alpha)\Omega\zeta_t A_t^{1-\alpha}(K_{jt}/L_{jt})^{\alpha}} = \varphi_t \quad \text{is also independent of j.}$$

Insert this result into (2.5) to deduce

$$P_t = [\sum_{j=1}^{M} \vartheta_j^{\theta_t}(P_t\varphi_t)^{1-\theta_t}]^{\frac{1}{1-\theta_t}} \quad \Rightarrow \quad \varphi_t = [\sum_{j=1}^{M} \vartheta_j^{\theta_t}]^{\frac{1}{\theta_t - 1}}.$$

(ii) By the definition of output and using part (i) above

$$Y_t \equiv \varphi_t \sum_{j=1}^{M} \zeta_t \Omega (K_{jt})^{\alpha} (A_t L_{jt})^{(1-\alpha)}$$

.

Since K_{jt}/L_{jt} are the same for all firms,

$$\sum_{j=1}^{M} \varphi_t\zeta_t\Omega(K_{jt})^{\alpha}(A_tL_{jt})^{(1-\alpha)} = \varphi_t\zeta_t\Omega(\frac{K_{jt}}{A_tL_{jt}})^{\alpha}\sum_{j=1}^{M} A_tL_{jt} = \varphi_t\zeta_t\Omega(\frac{K_{jt}}{A_tL_{jt}})^{\alpha-1}\sum_{j=1}^{M} K_{jt} = \varphi_t\zeta_t\Omega K_t^{\alpha}(A_tL_t)^{1-\alpha}$$

where $$K_t = \sum_{j=1}^{M} K_{jt} \ , \ L_t = \sum_{j=1}^{M} L_{jt} .$$

These imply that

$$\frac{K_t}{L_t} = \frac{K_{jt}}{L_j} \quad \text{for all } j$$

and

$$Y_t = \varphi_t \zeta_t \Omega K_t^{\alpha} (A_t L_t)^{1-\alpha} . \qquad \blacksquare$$

This proposition makes a clear point. In equilibrium, the value of output of intermediate goods produced by firm j, *in units of consumption goods,* is defined by the expression

$$(2.10) \qquad (\frac{P_{jt}}{P_t}\Psi_j)\zeta_t \Omega (K_{jt})^{\alpha} (A_t N_{jt})^{(1-\alpha)} = \varphi_t \zeta_t \Omega (K_{jt})^{\alpha} (A_t N_{jt})^{(1-\alpha)} .$$

Therefore, the proposition shows that adjusting for the factor Ψ_j, the relative price of each intermediate good to the price of the consumption good is the same for all intermediate goods. In addition, (2.9a) also shows that any change in the quality of intermediate good j shows up as a change in the relative price of intermediate goods to consumption good.

If firm j can raise its own ϑ_j, a possibility I study in Chapter 7, then for a large economy where the firm takes the price P as given, it follows from (2.6) that it will increase the demand for its own product since its product has a higher quality in relation to consumption. But then, following proposition 1, I show in (2.9a) that this will also change the prices of intermediate goods relative to consumption, which causes a higher aggregate exchange rate with consumption, measured by the change of a single term ϑ_j in φ_t. Since the value of profits, in units of the consumption good, of any firm k is

$$\Pi_{kt} = \varphi_t Y_{kt} - W_t N_{kt} - R_t K_{kt} ,$$

the profits of all firms rise because of this decrease in the price of consumption good relative to the price of intermediate good j.

If, on the other hand, for a given level of inputs, the quality of *all* intermediate goods rises by the same proportion ξ, it follows from (2.9a) that the new relative price $(\hat{P}_{jt}/\hat{P}_t)$ becomes

$$\frac{\hat{P}_{jt}}{\hat{P}_t} = \xi^{\frac{\theta_t}{\theta_t - 1}} [\sum_{i=1}^{M} \vartheta_i^{\theta_t}]^{\frac{1}{\theta_t - 1}} \equiv \xi^{\frac{\theta_t}{\theta_t - 1}} \varphi_t .$$

(2.6) implies that the demand for all intermediate goods will decline by a proportion $\xi^{-\theta_t}$ but the relative prices of consumption and intermediate goods will fall by the proportion $\xi^{-\theta_t/(\theta_t - 1)}$.

Analogous conclusions are drawn about measured productivity. Standard measures of TFP lead to errors due to the effect of changes in quality, as in (2.9b). Changes in observed productivity are caused by the two components in $\varphi_t(\zeta_t A_t^{1-\alpha})$: φ_t is due to changes in relative prices and $\zeta_t A_t^{1-\alpha}$ is due to technological improvements. Although these are partial equilibrium results, they suggest an important observation. Since improvements in the quality of intermediate goods lead to changes in the prices of such goods relative to the price of consumption, errors in price indexes used to measure real changes in intermediate goods cause errors in measured productivity. Measured productivity is then sensitive to the price indexes of the inputs. This theoretical result reappears in my study of the role of quality-improving R&D; it confirms conclusions drawn by Griliches (e.g. Griliches (1987), (1998)), by Gordon (1990) and others (e.g. Foster et. al. (2008)) about the impact of relative prices on measured productivity.

In a symmetric equilibrium $\vartheta_i = \vartheta$ and since the

$$\varphi_t = \vartheta^{\frac{\theta_t}{\theta_t - 1}} M^{\frac{1}{\theta_t - 1}} \text{ therefore if } \vartheta_i = \vartheta = \frac{1}{M} \text{ then } \varphi_t = \frac{1}{M}.$$

Since here I do not study the effect of changing quality, I assume for the rest of this chapter that $\vartheta_i = \vartheta = 1/M$ and $\Omega = M$. By (2.7c)-(2.7d), this implies that for each producer j the adjusted price ratio is $(P_{jt}\Omega\Psi_j)/P_t = 1$ and therefore after aggregation

(2.11a) $$W_t = \frac{(\theta_t - 1)}{\theta_t}(1-\alpha)(\zeta_t A_t)(K_t)^{\alpha}(A_t L_t)^{-\alpha}$$

(2.11b) $$R_t = \frac{(\theta_t - 1)}{\theta_t}\alpha\zeta_t(K_t)^{\alpha-1}(A_t L_t)^{1-\alpha}$$

(2.11c) $$Y_t = \zeta_t K_t^{\alpha}(A_t L_t)^{1-\alpha}$$

These are then the three equations for the firm in equilibrium.

2.4 Optimal household behavior

I have assumed that equity capital is owned by households and they rent it to the firms. Their saving decision based on their expected return on capital, realized in the next period when the capital demand by firms is formulated. Since I assume that the relative price of capital in terms of consumption is 1, the rental rate is endogenously determined by productivity and in equilibrium equals the interest rate plus depreciation. Total profits of the intermediate goods firms are paid as dividends to the owners of the shares which are traded on the stock market. The distinction between risky rental on capital employed and risky profits of the firm implies that the market value of the firm is the sum of its capital assets employed in production and its monopoly wealth, which is the market value of its monopoly profits.

My interest is in the response of the economy to changing monopoly power. For the moment, I only define the dynamic link between changing markup, or monopoly power, and the dynamics of productivity, so that in the equilibrium model developed here, market power is an endogenous variable. In Chapter 7 on R&D, I explore how firms can impact the dynamics of market power.

The dynamic optimization of the representative household takes the form of

$$\text{(2.12a)} \qquad \mathrm{Max}_{(C,I,L)} \sum_{\tau=0}^{\infty} \beta^{\tau}\left[\frac{1}{1-\sigma} C_{\tau}^{1-\sigma}\left(1-\frac{\mathcal{H}}{1+\eta} L_{\tau}^{1+\eta}\right)\right]$$

but in the simulations of the next section I will explore the effect of the alternative optimization

$$\text{(2.12a')} \qquad \mathrm{Max}_{(C,I,L)} \sum_{\tau=0}^{\infty} \beta^{\tau}\left[\frac{1}{1-\sigma} C_{\tau}^{1-\sigma} - \frac{1}{1+\eta} L_{\tau}^{1+\eta}\right],$$

subject to the budget constraint

$$\text{(2.12b)} \qquad C_t + K_{t+1} + P_t^s S_t = W_t L_t + K_t(R_t + (1-\delta)) + S_{t-1}(P_t^s + \Pi_t) \quad , \quad R_t = r_t + \delta .$$

S is the number of shares, L is fraction of time worked, P^S is the stock price, and R the rental rate, is the sum of interest plus depreciation. The parameter $\mathcal{H}$ pins down the steady state value of L at the value of 0.3 reflecting the estimate[3] that the fraction of time of a year spent at work is 30%. To state the dynamic restrictions, I specify the standard capital accumulation and technological change which, in this chapter, is taken to be exogenous

$$\text{(2.12c)} \qquad K_{t+1} = (1-\delta)K_t + I_t$$

$$\text{(2.12d)} \qquad \log(\zeta_{t+1}) = \lambda_{\zeta}\log(\zeta_t) + \varepsilon_{t+1}^{\zeta} \quad , \quad \varepsilon_{t+1}^{\zeta} \sim N(0,\sigma_{\zeta}^2)\text{, i.i.d.}$$

The dynamics of market power is formulated in terms of the markup notation

$$\mathcal{P}_t = \frac{\theta_t}{\theta_t - 1}$$

and reflects the theory developed in Chapter 1 that views technology and policy as the two forces that determine the dynamics of $\mathcal{P}_t$. Since there is no obvious aggregate indices that express well these two factors, the dynamics of market power which is centrally important for the theory, is being approximated by a Markov process

$$\text{(2.12e)} \quad \mathcal{P}_{t+1} = g\mathcal{P}_t^{\lambda_{\mathcal{P}}}\left[\zeta_{t+1}^{\mu_{\zeta}} \zeta_t^{(\mu_{\zeta})^2} \zeta_{t-1}^{(\mu_{\zeta})^3} \zeta_{t-2}^{(\mu_{\zeta})^4} \zeta_{t-3}^{(\mu_{\zeta})^5}\right] e^{\rho_{t+1}^{\mathcal{P}}} \; , \; \rho_{t+1}^{\mathcal{P}} \sim N(0,\sigma_{\mathcal{P}}^2) \quad , \rho_{t+1}^{\mathcal{P}} \text{ iid, independent of } \rho_{t+1}^{\zeta}$$

with the following interpretation:

[3] There does not appear to be a consensus in the literature on the value of this parameter. King and Rebelo (1999) estimate it to be 0.2 but such value is on the low side. It turns out that variations of this parameter have no effect on the main results reported here.

(i)*Technology* has two effects. First, the constant g - the trend growth of productivity - is the factor that introduces constant new market power. Second, the term $\zeta_{t+1}^{\mu_\zeta}\zeta_t^{(\mu_\zeta)^2}\zeta_{t-1}^{(\mu_\zeta)^3}\zeta_{t-2}^{(\mu_\zeta)^4}\zeta_{t-3}^{(\mu_\zeta)^5}$ is the effect of long term fluctuations of new innovations on market power, with geometric declining weights on past innovations. This term has one parameter μ_ζ, approximating with a finite sequence of five years the Koyck type distributed lag model and therefore requires a non-linear estimation procedure.
(ii) *Policy* and technological obsolescence is not represented by any specific variable, since containing market power is too complex a process to be summarized by any one index. Instead, it is represented by the key parameter $0 < \lambda_{\mathcal{P}} < 1$ which determines the rate at which current market power decays. Allowing the parameter to be close to 1 enables market power to consolidate and expand while lowering the parameter $\lambda_{\mathcal{P}}$ causes market power to dissipates more rapidly. That means that at each period, society chooses an economic policy that amounts to selecting a value of $\lambda_{\mathcal{P}}$. The more aggressive the policy is, the smaller is $\lambda_{\mathcal{P}}$. This reflects my basic approach to the problem of policy formation. Its main task is to promote as high innovation rate as possible but prevent it from consolidating and growing to become a large and permanent negative force. Note, however, that what I am not specifying is how the choice of policy alters $\lambda_{\mathcal{P}}$ and this will become an important problem in empirically identifying this parameter.

Combining the two forces, in steady state

$$\zeta^\star = 1 \quad , \quad \mathcal{P}^\star = g^{\frac{1}{1-\lambda_{\mathcal{P}}}} > 1 . \tag{2.13}$$

In the long run, technology is represented by the growth rate g and policy by the parameter $\lambda_{\mathcal{P}}$. In an economy without technological change $\zeta^\star = g = 1$, therefore it converges to the competitive economy where $\mathcal{P}^\star = 1$.

2.5 Equilibrium with market power

2.5.1 Equilibrium conditions

Since I am treating the continuum of identical households as a single agent, I can combine the first order conditions of the household with the pricing equations of each of the intermediate goods producers which incorporate the assumption of a symmetric equilibrium. The equilibrium conditions are then written in units of consumption as follows:

$$(C_t)^{-\sigma}(1-\frac{\mathcal{H}}{1+\eta}L_t^{1+\eta}) = \beta E_t[(C_{t+1})^{-\sigma}(1-\frac{\mathcal{H}}{1+\eta}L_{t+1}^{1+\eta})(R_{t+1} + (1-\delta))]$$

$$(C_t)^{-\sigma}(1-\frac{\mathcal{H}}{1+\eta}L_t^{1+\eta}) = \beta E_t[(C_{t+1})^{-\sigma}(1-\frac{\mathcal{H}}{1+\eta}L_{t+1}^{1+\eta})(\frac{P_{t+1}^s + \Pi_{t+1}}{P_t^s})]$$

$$\frac{\mathcal{H}}{1-\sigma}L_t^{\eta} = (1-\frac{\mathcal{H}}{1+\eta}L_t^{1+\eta})\frac{W_t}{C_t}$$

$$(2.14) \qquad W_t = \frac{1}{\mathcal{P}_t}(1-\alpha)\zeta_t g^{\,t}(K_t)^{\alpha}(g^{\,t}L_t)^{-\alpha}$$

$$R_t = \frac{1}{\mathcal{P}_t}\alpha\zeta_t(K_t)^{\alpha-1}(g^{\,t}L_t)^{1-\alpha}$$

$$S_t = 1$$

$$C_t + (K_{t+1} - K_t(1-\delta)) = Y_t = W_t L_t + K_t R_t + \Pi_t$$

$$Y_t = \zeta_t K_t^{\alpha}(A_t L_t)^{1-\alpha}.$$

To study these conditions I write the aggregate production function in the standard form of

$$Y_t = \zeta_t(K_t)^{\alpha}(A_t L_t)^{(1-\alpha)} = \zeta_t A_t(\frac{K_t}{A_t})^{\alpha}(L_t)^{1-\alpha} = \zeta_t A_t(k_t)^{\alpha}(L_t)^{1-\alpha} \quad , \quad k_t = (\frac{K_t}{A_t})$$

and the equilibrium conditions can now be scaled by the growth rate. Define first

$$c_t = (\frac{C_t}{A_t}) \ , \ w_t = (\frac{W_t}{A_t}) \ , \ y_t = (\frac{Y_t}{A_t}) \ , \ p_t^{\,s} = (\frac{P_s}{A_t}) \ , \ g = (\frac{A_{t+1}}{A_t}) \ , \ y_t = \zeta_t k_t^{\alpha} L_t^{1-\alpha}.$$

Keeping in mind that $\Pi_t = (1/\theta_t)Y_t = ((\mathcal{P}_t - 1)/\mathcal{P}_t)Y_t$, the conditions are

$$(2.15a) \qquad c_t + g k_{t+1} = \zeta_t k_t^{\alpha} L_t^{1-\alpha} + k_t(1-\delta)$$

$$(2.15b) \qquad (1 - \frac{\mathcal{H}}{1+\eta}L_t^{1+\eta}) = \beta E_t[(g\frac{c_{t+1}}{c_t})^{-\sigma}(1-\frac{\mathcal{H}}{1+\eta}L_{t+1}^{1+\eta})(R_{t+1} + (1-\delta))]$$

$$(2.15c) \qquad (1 - \frac{\mathcal{H}}{1+\eta}L_t^{1+\eta}) = \beta E_t[(g\frac{c_{t+1}}{c_t})^{-\sigma}(1-\frac{\mathcal{H}}{1+\eta}L_{t+1}^{1+\eta})\, g[\frac{p_{t+1}^{s} + ((\mathcal{P}_t - 1)/\mathcal{P}_t)\zeta_t k_{t+1}^{\alpha} L_{t+1}^{1-\alpha}}{p_t^{s}}]$$

$$(2.15d) \qquad \frac{\mathcal{H}}{1+\sigma}L_t^{\eta} = (1 - \frac{\mathcal{H}}{1+\eta}L_t^{1+\eta})\frac{w_t}{c_t}$$

$$(2.15e) \qquad w_t = \frac{1}{\mathcal{P}_t}(1-\alpha)\zeta_t k_t^{\alpha} L_t^{-\alpha}$$

$$(2.15f) \qquad R_t = \frac{1}{\mathcal{P}_t}\alpha\zeta_t k_t^{\alpha-1} L_t^{1-\alpha}.$$

Since aggregate labor supply is constant at the level of 1, the asymptotic growth factor is g which is independent of θ_t.

2.5.2 Steady state response to rising monopoly power

Although θ_t changes over time, monopoly power is highly persistent and changes slowly. Therefore, for any $\theta_t = \theta$, if all other endogenous variables adjust fast enough, the economy will converge to a *conditional* $\mathcal{P}$-steady state in which all equilibrium variables are, in fact, functions of

θ. It is then instructive to study the change in the steady state variables in response to a lower value of θ, which is a higher $\mathcal{P}$. If the effect on another variable is monotonic, it may later be the primary *direction* in which that variable will change in response to a dynamic sequence of falling values of θ, representing a cumulative process of rising monopoly power. The equilibrium conditional $\mathcal{P}$-steady state is expressed by the following set of equations:

$$c^\star + gk^\star = (k^\star)^\alpha (L^\star)^{1-\alpha} - k^\star(1-\delta) \tag{2.16a}$$

$$1 = \beta g^{(-\sigma)}[R^\star + (1-\delta)] \tag{2.16b}$$

$$p^{s\star} = \beta g^{(1-\sigma)}[p^{s\star} + \frac{1}{\theta}(k^\star)^\alpha (L^\star)^{1-\alpha}] \tag{2.16c}$$

$$\frac{\mathcal{H}}{1+\sigma}(L^\star)^\eta = (1 - \frac{\mathcal{H}}{1+\eta}(L^\star)^{1+\eta})\,\frac{w^\star}{c^\star} \tag{2.16d}$$

$$w^\star = \frac{(\theta-1)}{\theta}(1-\alpha)(k^\star)^\alpha (L^\star)^{-\alpha}. \tag{2.16e}$$

$$R^\star = \frac{(\theta-1)}{\theta}\alpha(k^\star)^{\alpha-1}(L^\star)^{1-\alpha}. \tag{2.16f}$$

This is a system of 6 equations in the 6 unknowns $(k^\star, c^\star, p^{s\star}, L^\star, w^\star, R^\star)$, all functions of θ. Since I want to study analytically the way this $\mathcal{P}$-steady state responds to change in $\mathcal{P}$ it is convenient to transform it once more by defining

$$\tilde{k}_t = (\frac{K_t}{A_t L_t}),\ \tilde{c}_t = (\frac{C_t}{A_t L_t}),\ \tilde{w}_t = (\frac{W_t}{A_t L_t}),\ \tilde{y}_t = (\frac{Y_t}{A_t L_t}),\ \tilde{p}_t^{\,s} = (\frac{P_s}{A_t L_t}),\ g = (\frac{A_{t+1}}{A_t}). \tag{2.17}$$

This transformation could have been used at the outset, instead of (1.24), but this would have complicated the dynamics of the resulting system since $\tilde{k}_{t+1}$ is a date t random variable while k_{t+1} is not. Using (1.27), I can rewrite the $\mathcal{P}$-steady state equations as

$$\tilde{c}^\star + g\tilde{k}^\star = (\tilde{k}^\star)^\alpha - \tilde{k}^\star(1-\delta) \tag{2.18a}$$

$$1 = \beta g^{-\sigma}[R^\star + (1-\delta)] \tag{2.18b}$$

$$\tilde{p}^{s\star} = \beta g^{(1-\sigma)}[\tilde{p}^{s\star} + \frac{1}{\theta}(\tilde{k}^\star)^\alpha] \tag{2.18c}$$

$$\frac{\mathcal{H}}{1+\sigma}(L^\star)^\eta = (1 - \frac{\mathcal{H}}{1+\eta}(L^\star)^{1+\eta})\,\frac{\tilde{w}^\star}{\tilde{c}^\star} \tag{2.18d}$$

$$\tilde{w}^\star = \frac{(\theta-1)}{\theta}(1-\alpha)(\tilde{k}^\star)^\alpha. \tag{2.18e}$$

$$R^\star = \frac{(\theta-1)}{\theta}\alpha(\tilde{k}^\star)^{\alpha-1}. \tag{2.18f}$$

The first crucial point to note about this formulation of the $\mathcal{P}$-steady state is the following:

Proposition 2.2: The steady state growth rate and the interest rate are independent of the degree of monopoly power.
Proof: The growth rate of the system is a constant, g, and since $R^{\star} = r^{\star} + \delta$, it follows from (2.18b) that the steady state interest rate is also independent of θ. ■

Since there are long periods of rising or falling market power, one is interested in the response of the economy to a *sequence* of rising or falling rates of market power. It is helpful to understand how the decline in investment, in response to rising monopoly power, *is the main force that drives the change in the economy*.

Proposition 2.3: $\tilde{k}^{\star}$ is monotonically rising in θ, hence a rising monopoly power $\mathcal{P}_t$ lowers the level of the capital in the $\mathcal{P}$-steady state, but it has the following *permanent* effects: (i) *lower* output level, (ii) *lower* consumption level, (iii) *lower* level of investment, (iv) *lower* wage rate, (v) *lover* labor participation $L^{\star}$, (vi) *lower* capital/output ratio, (vii), *lower* investment/output ratio, (viii) higher ratio of wealth to capital.

Proof: I will first show that $(\tilde{k}^{\star}, \tilde{c}^{\star}, \tilde{p}^{s\star}, \tilde{w}^{\star}, \tilde{R}^{\star}, L^{\star})$ rise with θ and then I show it implies that $(k^{\star}, c^{\star}, p^{s\star}, w^{\star}, R^{\star}, L^{\star})$ rise as well. Note first the derivative

$$\frac{d[(\theta-1)/\theta]}{d\theta} = \frac{1}{\theta^2} > 0.$$

Since in (2.18b) the rental $R^{\star}$ does not change with θ, it requires $\frac{(\theta-1)}{\theta}\alpha(\tilde{k}^{\star})^{\alpha-1} = \text{constant}$. But a differentiation of this expression implies

$$(\alpha-1)(\tilde{k}^{\star})^{(\alpha-2)}\frac{(\theta-1)}{\theta}\frac{d\tilde{k}^{\star}}{d\theta} + (\tilde{k}^{\star})^{\alpha-1}\frac{1}{\theta^2} = 0$$

therefore

$$\frac{d\tilde{k}^{\star}}{d\theta} = \frac{\theta}{(\theta-1)\alpha(1-\alpha)}\tilde{k}^{\star}\left(\frac{1}{\theta^2}\right) > 0.$$

As θ declines and monopoly power rises, $\tilde{k}^{\star}$ declines.
(i) $\tilde{y}^{\star} = (\tilde{k}^{\star})^{\alpha}$ which is monotonically falling with a decline in $\tilde{k}^{\star}$.
(ii) Investment equals $\tilde{k}^{\star}[g-(1-\delta)]$ and is also monotonically falling with a decline in $\tilde{k}^{\star}$.
(iii) By (2.18a), $\tilde{c}^{\star} = (\tilde{k}^{\star})^{\alpha} - \tilde{k}^{\star}[g-(1-\delta)]$ which monotonically falls with a decline of $\tilde{k}^{\star}$ since $\alpha(\tilde{k}^{\star})^{\alpha-1} > [g-(1-\delta)]$. This decline results from of the fact that for any optimal investment, $\tilde{k}^{\star}$ is *lower* than the Golden Rule level, defined by $\alpha(\hat{k})^{\alpha-1} = [g-(1-\delta)]$.

(iv) To see why the wage rate declines, rewrite (1.28e) as

$$\tilde{w}^\star = [\frac{(\theta - 1)}{\theta}(1-\alpha)(\tilde{k}^\star)^{\alpha-1}]\tilde{k}^\star. \tag{2.18d'}$$

By Proposition 2.2, $[\frac{(\theta-1)}{\theta}(1-\alpha)(\tilde{k}^\star)^{\alpha-1}]$ is a positive constant, independent of θ, therefore

$$\frac{d\tilde{w}^\star}{d\theta} = [\frac{(\theta-1)}{\theta}(1-\alpha)(\tilde{k}^\star)^{\alpha-1}]\frac{d\tilde{k}^\star}{d\theta} > 0.$$

(v) To prove that $L^\star$ rises with θ, rewrite (2.18d) in the form

$$V(\theta) = \frac{\frac{\mathcal{H}}{1+\sigma}(L^\star)^\eta}{(1-\frac{\mathcal{H}}{1+\eta}(L^\star)^{1+\eta})} = \frac{\tilde{w}^\star}{\tilde{c}^\star}.$$

Differentiating the right hand side, I find that

$$\frac{\frac{dV(\theta)}{d\theta}}{\frac{dL^\star}{d\theta}} = \frac{\eta\frac{\mathcal{H}}{1+\sigma}(L^\star)^{\eta-1}(1-\frac{\mathcal{H}}{1+\eta}(L^\star)^{1+\eta})+\frac{\mathcal{H}}{1+\sigma}(L^\star)^\eta\mathcal{H}(L^\star)^\eta}{(1-\frac{\mathcal{H}}{1+\eta}(L^\star)^{1+\eta})^2} > 0. \tag{2.19}$$

On the other hand

$$\frac{d(\frac{\tilde{w}^\star}{\tilde{c}^\star})}{d\theta} = \frac{1}{\tilde{c}^\star}\frac{d\tilde{w}^\star}{d\theta} - (\frac{\tilde{w}^\star}{(\tilde{c}^\star)^2})\frac{d\tilde{c}^\star}{d\theta}. \tag{2.20}$$

Now use (2.18a) and (2.18e) to deduce

$$\frac{1}{\tilde{c}^\star}\frac{d\tilde{w}^\star}{d\theta} - (\frac{\tilde{w}^\star}{(\tilde{c}^\star)^2})\frac{d\tilde{c}^\star}{d\theta} = \left[\frac{1}{\tilde{c}^\star}(\frac{1}{\theta^2}(1-\alpha)\tilde{k}^{\star\alpha} + \frac{\theta-1}{\theta}(1-\alpha)\tilde{k}^{\star\alpha-1}) - \frac{\tilde{w}^\star}{\tilde{c}^{\star 2}}(\alpha\tilde{k}^{\star(\alpha-1)} - (g-(1-\delta))\right]\frac{d\tilde{k}^\star}{d\theta}.$$

But then, detailed computations lead to the conclusion

$$(\frac{1}{\theta^2}(1-\alpha)\frac{\tilde{k}^{\star\alpha}}{\tilde{c}^\star}+\frac{\theta-1}{\theta}(1-\alpha)\frac{\tilde{k}^{\star\alpha-1}}{\tilde{c}^\star})-\frac{\tilde{w}^\star}{\tilde{c}^{\star 2}}(\alpha\tilde{k}^{\star(\alpha-1)}-(g-(1-\delta))=(\frac{\tilde{w}^\star}{\tilde{c}^\star})(\frac{1}{\theta(\theta-1)}+(\frac{\tilde{w}^\star}{\tilde{c}^\star})\frac{1}{\tilde{k}^\star}(1-\alpha)(\frac{\tilde{k}^{\star\alpha}}{\tilde{c}^\star}-1)>0.$$

Using this last inequality with (2.19) and (2.20) lead to the implication that

(2.21) $$\frac{dL^\star}{d\theta} > 0.$$

(v) The capital/output ratio is $\dfrac{\tilde{k}^\star}{(\tilde{k}^\star)^\alpha} = (\tilde{k}^\star)^{1-\alpha}$, therefore one concludes that

$$\frac{d(\tilde{k}^\star)^{1-\alpha}}{d\theta} = (1-\alpha)(\tilde{k}^\star)^{-\alpha}\frac{d(\tilde{k}^\star)}{d\theta} > 0.$$

(vi) The investment/ouput ratio is $\dfrac{\tilde{k}^\star[g-(1-\delta)]}{(\tilde{k}^\star)^\alpha} = (\tilde{k}^\star)^{(1-\alpha)}[g-(1-\delta)]$, therefore

$$\frac{d[(\tilde{k}^\star)^{(1-\alpha)}(g-(1-\delta))]}{d\theta} = (1-\alpha)(\tilde{k}^\star)^{-\alpha}\frac{d(\tilde{k}^\star)}{d\theta}[g-(1-\delta)] > 0.$$

(vii) Wealth is $(\tilde{p}^{s\star} + \tilde{k}^\star)$, which is the sum of capital and stock price. To define it use the notation

$$\hat{z} = \frac{\beta g^{(1-\sigma)}}{1-\beta g^{(1-\sigma)}}.$$

By (2.14c), the value of the stock is

(2.22) $$\tilde{p}^{s\star} = \hat{z}\frac{(\tilde{k}^\star)^\alpha}{\theta}$$

hence, wealth/capital ratio is

$$\frac{\tilde{p}^{s\star} + \tilde{k}^\star}{\tilde{k}^\star} = \frac{\hat{z}\dfrac{(\tilde{k}^\star)^\alpha}{\theta} + \tilde{k}^\star}{\tilde{k}^\star} = \hat{z}\frac{(\tilde{k}^\star)^\alpha}{\theta} + 1$$

hence $$\frac{d[(\tilde{p}^{s\star} + \tilde{k}^\star)/\tilde{k}^\star]}{d\theta} = \hat{z}[(\frac{1}{\theta})(\alpha-1)(\tilde{k}^\star)^{\alpha-2}\frac{d\tilde{k}^\star}{d\theta} - \frac{(\tilde{k}^\star)^{(\alpha-1)}}{\theta^2}] < 0.$$

This completes the proof that $(\tilde{k}^\star, \tilde{c}^\star, \tilde{p}^{s\star}, \tilde{w}^\star, \tilde{R}^\star, L^\star)$ rise with θ. To prove that this implies that $(k^\star, c^\star, p^{s\star}, w^\star, R^\star, L^\star)$ also rise with θ, consider any variable

$$\tilde{X} = \frac{X}{L^\star} \quad , \quad \frac{dL^\star}{d\theta} > 0 \quad , \quad \frac{d\tilde{X}^\star}{d\theta} > 0.$$

Differentiating with respect to θ lead to

$$\frac{d\tilde{X}^\star}{d\theta} = (\frac{1}{L^\star})\frac{dX^\star}{d\theta} - (\frac{X^\star}{L^{\star 2}})\frac{dL^\star}{d\theta} \quad \Rightarrow \quad \frac{dX^\star}{d\theta} = L^\star\frac{d(\tilde{X}^\star)}{d\theta} + (\frac{X^\star}{L^\star})\frac{dL^\star}{d\theta} > 0. \qquad \blacksquare$$

The effect of rising monopoly power on stock prices is more subtle. By (2.22) it is clear that increased monopoly power increases the share of monopoly profits in output *but it also lowers output!* There is therefore a threshold above which the level of monopoly power lowers stock prices.

Proposition 2.4: A rising monopoly power increases the steady state level of the stock price if $\theta > 1 + \alpha/(1-\alpha)$.

Proof: Differentiation of (2.22) results in the condition

$$\frac{dp^{s\star}}{d\theta} = \hat{z}\,[-\frac{(k^\star)^\alpha}{\theta^2} + \frac{1}{\theta}(k^\star)^{\alpha-1}\frac{\theta}{(\theta-1)(1-\alpha)}\frac{k^\star}{\theta^2}] = \hat{z}\frac{(k^\star)^\alpha}{\theta^2}[\frac{\alpha}{(\theta-1)(1-\alpha)} - 1]$$

therefore

$$\frac{dp^{s\star}}{d\theta} < 0 \quad \text{if} \quad \theta > 1 + \frac{\alpha}{1-\alpha}.$$ ■

For $\alpha = 0.33$, the condition above requires $\theta > 1.49$, which requires the profit share to be less than 67%. In Chapter 4, I show that this share fluctuates between 0 and 30%. Hence for all relevant parameter values, rising monopoly power causes steady state stock prices to rise.

2.5 Dynamic Quantitative Effects of Market Power on Macroeconomic Variables

Steady state analysis offers a partial description of the effect of market power on the economy, and on some issue, it is misleading. Since most of the time the economy is not in steady state, I devote this section to study the effect of such power on the dynamic evolution of the economy *away from steady state*. This will be carried out with computer simulations. Due to the novelty of the subject at hand, and since only limited data are available to measure market power, the simulations in this chapter offer qualitative results on the direction and on the order of magnitude of the effect of market power on market performance, and should thus be taken as part of my theoretical argument.

2.5.1 Estimating parameter values by identifying periods with no policy to contain market power

Values of most parameters are specified based on well known econometric estimates. The key model parameters are then: $\alpha = 0.32$, $\beta = 0.98$, $\sigma = 0.98$, $\delta = 0.08$, $\eta = 2.0$ in the case of additive utility and $\eta = 2.00$ and $\mathcal{H} = 2.36$ in the case of multiplicative utility where these parameters are chosen so the Frisch elasticity equals 0.50 and steady state participation rate L = 0.30. I set g = 1.014, which is a difficult choice since estimates of recent productivity trends reveal a decline in the rate of productivity growth compared to earlier in the 20th century. Arguments about secular stagnation suggest a decline of the trend based on relatively small number of recent observations and such inference may be questioned.

The dynamic parameters are $(\lambda_\zeta, \sigma_\zeta, \lambda_\mathcal{P}, \mu_\zeta, \sigma_\mathcal{P})$ and the main difficulty here is the data used to estimate them. The annual data I used for $\mathcal{P}$ are the data I develop in chapter 4, where a detailed explanation of that data is available. Data on ζ_t requires a choice of a source for Total Factor Productivity (TFP), and this is a wide field with different approaches to the problem. The objections to TFP data are well known. Nevertheless, since it is needed only for estimating the model parameters above, I used mostly the Bank of France data developed by Bergeaud et. al (2016), because it cover the years from 1890 to 2019. The variable ζ_t was computed as the deviation from the trend of the estimated cumulative productivity. To increase the reliability of the estimated values of $(\lambda_\zeta, \sigma_\zeta)$ I also used the Federal Reserve Bank of San Francisco data files from 1947 to 2019. The main difference between the two sources is the significant adjustment for capacity utilization used in the San Francisco data. Data without adjustment for capacity utilization is closer to the Bank of France estimates, while the data with that adjustment are significantly different.

The estimated equations with annual data are then

(2.23a) $$\log(\zeta_{t+1}) = \lambda_\zeta \log(\zeta_t) + \varepsilon^{\zeta}_{t+1}$$

(2.23b) $$\log\mathcal{P}_{t+1} = \log(g) + \lambda_{\mathcal{P}}\log\mathcal{P}_t + \mu_\zeta \log\zeta_{t+1} + \mu_\zeta^2 \log\zeta_t + \mu_\zeta^3 \zeta_{t-1} + \mu_\zeta^4 \log\zeta_{t-2} + \mu_\zeta^5 \log\zeta_{t-3} + \rho^{\mathcal{P}}_{t+1} \quad , \quad \mathcal{P}_t > 1 .$$

Changes in policy are defined as unexpected change in the parameter $\lambda_{\mathcal{P}}$ and these equations do not specify how any particular policy change alters this parameter. If one estimates the equations for a *specific period*, one can deduce from the estimated value of $\lambda_{\mathcal{P}}$ the intensity of policy that was used in that economy during that time. Such analysis is useful as a guide to altering a policy, if the resulting inequality is socially unacceptable.

Among the important questions which the model may help answer is the degree of inequality that would be experienced by an economy if no policy is used to contain the growth of market power. Since the U.S. had experienced such periods, this assessment may be possible. I will show in Chapter 4 that during the years from 1889 to 1901 and from 1985 to 2017 there was no effective policy to contain market power in the U.S. Moreover, from 1901 to 1985 the prevailing policy aimed to attain a reasonable degree of egalitarian income distribution but with some variability in policy formulation and enforcement. Important legal changes were enacted by the reform movement after 1901 and most were enforced, but these changes were introduced slowly due to the strong resistance to them. A formal egalitarian policy was firmly adopted in the Great Depression, and that remained in effect up to the 1970s, after which is was weakened by various factors discussed in Chapter 4. These two policy shifts create *a natural experiment* for estimating a laissez faire policy, or lax-policy or even no-policy, parameter $\lambda^H_{\mathcal{P}}$ that was in effect during the lax-policy era of the years 1889-1901 and 1985-2017, and an active-policy parameter $\lambda^L_{\mathcal{P}}$ that was operative during the egalitarian era of 1902-1984. The difference of parameter values is expected due to the fact that the policy changes in 1901 and in 1985 were sharp regime shifts. Although the policies that followed those shifts remained in force a long time, I show in Chapter 4 that the egalitarian policy from 1901 to 1985 was not applied uniformly during these 84 years. The reforms after 1901 were enforced but they were legally enacted slowly. Further reforms were enacted but not enforced during the Great Depression and World War II, when cooperation between business and government was needed and the imposition of strong policy to contain market power was not viewed as advisable by the Roosevelt Administration. In fact, I show in chapter 4 that during that period market power *actually rose*.

Starting with $(\lambda_\zeta, \sigma_\zeta)$ Table 2.1 presents estimates of these parameters and of the trend in productivity growth. There is no evidence λ_ζ has changed materially and the average of the three estimates for the period from 1985 to 2019 is 0.9085. The different data sources lead to different estimates of σ_ζ. It has declined rapidly since early in the 20th century, and the average of the three estimates for the years from 1985 to 2019 is 0.0109. Finally, as I noted earlier, it is too early to determine that secular stagnation renders the decline in the trend of productivity permanent. Thinking about the future, my choice for the three parameters is then

$$(\lambda_\zeta = 0.909 \, , \, \sigma_\zeta = 0.0109 \, , \, g = 1.014) \tag{2.24}$$

Table 2.1: Estimates of λ_ζ , σ_ζ and of Trend Productivity g

Data Source and Years Covered	λ_ζ	σ_ζ	Trend g
Bank of France Data			
1890-2019	0.9595	0.0358	1.0181
	(0.0286)		
1947-2019	0.8814	0.0136	1.0129
	(0.0422)		
1985-2019	0.9617	0.0077	1.0120
	(0.0688)		
San Francisco Fed (no utilization adjustment)			
1947-2019	0.9098	0.0169	1.0109
	(0.0397)		
1985-2019	0.8655	0.0120	1.0093
	(0.0966)		
San Francisco Fed (with utilization adjustment)			
1947-2019	0.9367	0.0131	1.0093
	(0.0819)		
1985-2019	0.8983	0.0129	1.0093
	(0.0793)		

Turning to $(\lambda_{\mathcal{P}}, \mu_\zeta, \sigma_{\mathcal{P}})$, Table 2.2 presents estimates of these parameters for different periods. I use the Bank of France data since it is essential to include the years from 1889 to 1901. In addition to variables in (2.23b) I experiment with other variables that could have impact. On the side of technology, "Patents/Population" is the number of patents granted in that year, per million of population, and "output/man" is the percent change in output per man-hour. On the policy side "Presidential Party" is a dummy variable taking the value 1 for Democratic presidents and 0 for Republican presidents. "Max Tax" is the top marginal income tax rate in the year. Since the effect of policy is measured by the parameters $\lambda_{\mathcal{P}}^{H}$ for periods of no policy and $\lambda_{\mathcal{P}}^{L}$ for periods of active policy, I estimate only the interaction terms of Presidential party and Max Tax with market power.

The only statistically significant interaction term is the maximal tax rate with market power, reflecting the fact that high tax rates had an indirect effect on containing market power. Output per man-hour is obviously correlated with TFP and is a less satisfactory alternative.

Table 2.2: Estimated Parameters in Equation (2.23b)

Years Covered	Const.	H	L		H Pres Party	L Pres Party	H Max Tax	L Max Tax	Pat/Pop	Output/ man	σ_f	R^2
All Years: 1894-2017												
	1.0324	0.8672	0.7368	0.3735							0.0405	0.787
	(0.0100)	(0.0563)	(0.0521)	(0.0800)								
	1.0415	1.0312	0.6731	0.3858	-0.0136	-0.0086	-0.1096	0.0130			0.0390	0.803
	(0.0111)	(0.0801)	(0.0565)	(0.0857)	(0.0131)	(0.0103)	(0.0468)	(0.0150)				
	1.0434	1.0397	0.6744	0.3854	-0.0132	-0.0085	-0.1102	0.0125	-0.0056		0.0390	0.803
	(0.0164)	(0.0978)	(0.0573)	(0.0862)	(0.0135)	(0.0103)	(0.0472)	(0.0153)	(0.0371)			
	1.0222	1.0310	0.7671	-0.0677	-0.0056	0.0000	-0.0808	0.0057	-0.0045	0.7653	0.0350	0.841
	(0.0154)	(0.0885)	(0.0537)	(0.1384)	(0.0122)	(0.0089)	(0.0426)	(0.0138)	(0.0335)	(0.1574)		
Exclude: 1901-1932	1.0271	0.8979	0.8011	0.3166							0.0346	0.862
	(0.0092)	(0.0507)	(0.0502)	(0.0976)								
	1.0343	1.0463	0.7151	0.3506	-0.0127	-0.0089	-0.0972	0.0182			0.0327	0.877
	(0.0128)	(0.0701)	(0.0776)	(0.0972)	(0.0111)	(0.0107)	(0.0415)	(0.0275)				
	1.0351	1.0524	0.7144	0.3504	-0.0123	-0.0089	-0.0971	0.0187	-0.0036		0.0327	0.877
	(0.0152)	(0.0913)	(0.0783)	(0.0978)	(0.0116)	(0.0107)	(0.0418)	(0.0281)	(0.0343)			
	1.0224	1.0310	0.7587	0.0998	-0.0077	-0.0046	-0.0829	0.0137	0.0010	0.5711	0.0308	0.891
	(0.0149)	(0.0873)	(0.0740)	(0.1819)	(0.0111)	(0.0100)	(0.0398)	(0.0266)	(0.0326)	(0.2090)		
Exclude: 1932-1953	1.0207	0.9025	0.7728	0.4859							0.0389	0.797
	(0.0124)	(0.0616)	(0.0583)	(0.0970)								
	1.0346	1.0411	0.7018	0.5040	-0.0134	-0.0094	-0.1089	0.0068			0.0372	0.815
	(0.0132)	(0.0780)	(0.0693)	(0.1041)	(0.0126)	(0.0116)	(0.0456)	(0.0161)				
	1.0355	1.0457	0.7032	0.5038	-0.0131	-0.0094	-0.1091	0.0065	-0.0029		0.0372	0.815
	(0.0172)	(0.0996)	(0.0721)	(0.1047)	(0.0131)	(0.0117)	(0.0459)	(0.0165)	(0.0386)			
	1.0157	1.0366	0.8162	-0.2062	-0.0037	0.0000	-0.0725	-0.0063	-0.0063	0.9493	0.0325	0.858
	(0.0153)	(0.0879)	(0.0674)	(0.1322)	(0.0116)	(0.0096)	(0.0406)	(0.0145)	(0.0340)	(0.1665)		
Post War : 1946 - 2017	1.0136	0.9218	0.8694	0.4076							0.0249	0.884
	(0.0108)	(0.0524)	(0.0536)	(0.1189)								
	1.0026	0.9565	0.7548	0.4303	0.0003	-0.0078	0.0068	0.0477			0.0243	0.889
	(0.0225)	(0.0631)	(0.0959)	(0.1275)	(0.0095)	(0.0085)	(0.0661)	(0.0343)				
	0.9926	0.8814	0.7362	0.4249	-0.0025	-0.0070	0.0205	0.0524	0.0339		0.0241	0.891
	(0.0243)	(0.0935)	(0.0972)	(0.1283)	(0.0098)	(0.0085)	(0.0671)	(0.0345)	(0.0312)			
	0.9863	0.8966	0.7695	0.2940	-0.0008	-0.0054	0.0297	0.0502	0.0284	0.3256	0.0236	0.895
	(0.0243)	(0.0933)	(0.0982)	(0.1947)	(0.0098)	(0.0085)	(0.0647)	(0.0339)	(0.0311)	(0.2359)		

Considering $(\lambda_{\mathcal{P}}^{H}, \lambda_{\mathcal{P}}^{L})$, the third set of estimates, based on excluding 1932-1953 but including data for 1889-1901 and 1985-2017, represent better these two policy regimes because antitrust policy was only superficially enforced from 1932 to 1953. Given that in 2017 Max Tax was 0.37 and the President was a Republican, I conclude that $0.90 < \lambda_{\mathcal{P}}^{H} < 1$ and $0.74 < \lambda_{\mathcal{P}}^{L} < 0.82$. Turning to μ_{ζ}, this is an important parameter with impact on the convergence properties of the model, therefore it is best to consider only long time series for higher reliability, which suggest that $0.32 < \mu_{\zeta} < 0.39$. To be on the conservative side I select $\mu_{\zeta} = 0.37$. Turning to $\sigma_{\mathcal{P}}$, Table 2.2 shows that, like σ_{ζ}, it has declined sharply, and may also reflect declining errors in observation over time. My final selection is then $\lambda_{\mathcal{P}}^{H} = 0.95$, $\lambda_{\mathcal{P}}^{L} = 0.80$, $\sigma_{\mathcal{P}} = 0.020$, $\mu_{\zeta} = 0.37$.

The estimated constant term is of particular interest because it allows a check on the consistency of the theory developed here. The theory underlying the model (2.23b) postulates the growth rate of productivity as a constant force that propels a constant market power. However, it does not need to be g itself, and may be χg for some constant χ. The estimated constant in Table 2.2 supports the hypothesis of χ =1 and shows that the constant has declined, with the lowest value of 1.36% in the post Wold War II period. Based on the Bank of France data, the estimated constant growth rate of productivity for the post war period reported in Table 2.1 is 1.29% and I have set the constant for the simulation work in the next section at 1.40%.

Since the aim is to highlight some key features of the theory, I later comment on the sensitivity of the results to parameter values. This is particularly important with respect to $(\lambda_{\mathcal{P}}^{H}, \lambda_{\mathcal{P}}^{L}, \sigma_{\mathcal{P}}, \mu_{\zeta})$ - the parameters of the transition equation of $\mathcal{P}$, which are new to the literature and are probably the least reliably estimated.

Finally, the theoretical experiments that follow are computed with perturbation methods using 4th order approximation to ensure high accuracy. The constraint $\mathcal{P} > 1$ was enforced with a Chen-Mangasarian (1996) smoothing function.

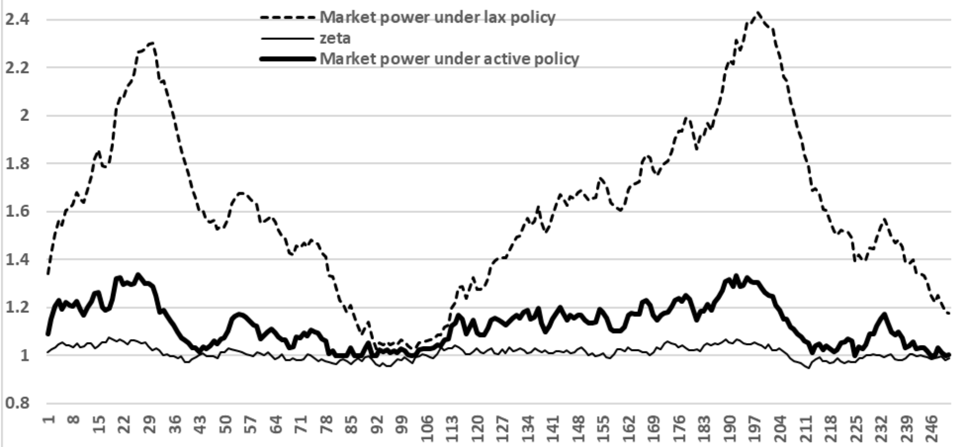
2.5.2 *The effect of market power in a fixed policy regime*

To understand the effect of market power it is important to focus first on long run tendencies. In many of the figures below I report results of simulating 250 years and the reason for that is that market power changes slowly. The autoregressive parameter that reflects policy has the obvious effect on such long term evolution, but the role of technology is in generating new market power. The more innovations are made, the more rapid is the rise in market power. Consequently, technology impacts the rate at which market power grows or falls through *runs in productivity*. A *productivity run* is a sequence of values of ζ_t whose deviations from the mean of 1 has the same sign. During a long duration run of $\zeta_t > 1$ the growth rate of productivity rises above trend and the economy experiences a rapid rate of technological changes an increased rate of innovations and consequently a rising market power. During a long duration run of $\zeta_t < 1$ the growth rate of productivity falls below trend and the economy experiences a productivity slowdown, a decline in the rate of innovations and declining market power. Since ζ_t follows a Markov process, such runs do form regularly, depending upon the three parameters of persistence $(\lambda_{\mathcal{P}}^{H}, \lambda_{\mathcal{P}}^{L}, \lambda_{\zeta})$. The duration of the runs determine the evolution of market power. This is the mechanism that guides the changes in market power in all Figures. The main results of the study are recorded next with a sequence of statements, followed by explanations.

A. Market power changes slowly, driven by policy and by random productivity runs. Figure 2.1 reports the dynamics of market power over 250 years under the impact of a sample of ζ_t values that is used twice to compute market power under each of the two policy regimes. The figure also reports the sample values of ζ_t. It shows that market power changes very slowly and variations in it take decades to take shape. In the experiment reported in Figure 2.1, the first event of rising market power is driven by a long productivity run of $\zeta_t > 1$ which, in turn, cannot sustain the high values of $\mathcal{P}$ since although $\zeta_t > 1$, it is declining. The decline of market power is accelerated by the long run of $\zeta_t < 1$ that follows. A similar pattern arises again so that on average, *extreme* values of market power occur endogenously with a frequency of once in about 100 year.

Figure 2.1 also exhibits the difference in market power under the two policy regimes. The steady state markup is 1.089 under the active policy and 1.321 under the laissez faire policy, but random fluctuations keep it away from steady state most of the time. Under the impact of the specific random sample simulated in Table 2.1, the active policy restricts market power to less than 1.336, but most of the time it is less than 1.2. On the other hand the laissez faire policy permits market power to reach as high as 2.429 but to spend most of its time less than 2.0. Note that a laissez faire regime does not imply market power always rise and the figure shows that it falls during periods of productivity slowdown which will occur under any policy regime. Long productivity runs occur with a frequency of about once of every 50 years.

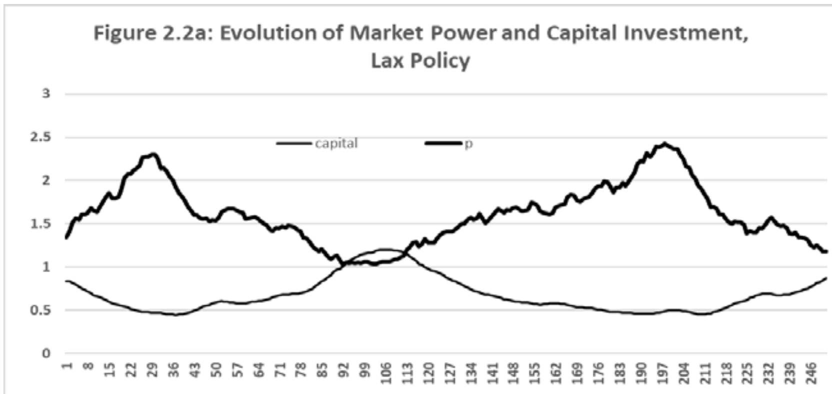
Figure 2.1: Dynamics of Market Power Under Alternative Policies



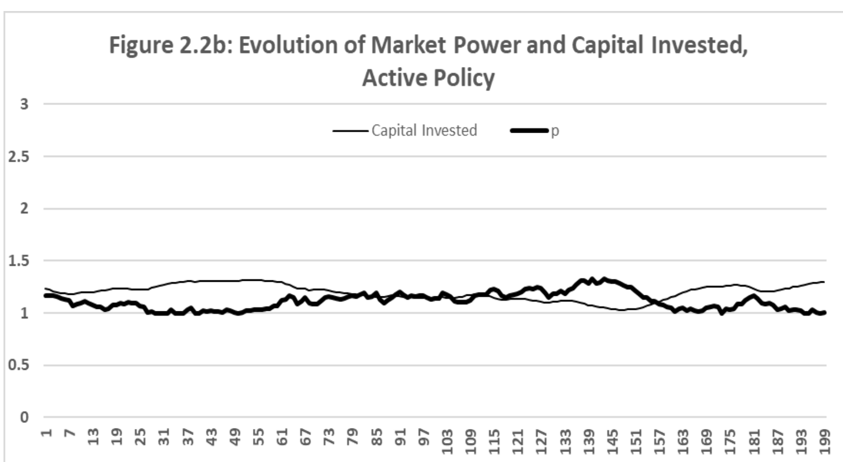
<u>*B. Revolution or limits on inequality under a lax, laissez faire, policy regime.*</u> To appreciate the extreme nature of the results in Figure 2.1 note that a markup of 2 implies the share of profits is 50% of total income. The model does not formulate a specific degree of inequality that can be sustained in a democratic society, but the inequality that would be realized if the share of profits reaches 50% would not be tolerated by a democracy. Does that mean an arm resistence, revolution or democratic overurning of the policy? This is not intended as a mathematical model of revolutions since it does not formulate resistance to rising inequality or any acts to expropriate the income and wealth of the rich. But if one postulates that the degree of inequality tolerated by society would limit the share of profits to remain less than 30%, then when $\mathcal{P}$ reaches 1.428, either the policy regime is overturned by a democratic process or the model breaks down as being infeasible.

The important fact is, however, that the model *predicts* a liberaterian, lax, policy regime that does not limit the expansion of market power will, with probability 1, face levels of inequalities that are incompatible with democracy. Moreover, all plausible limits on inequality will be broken with regularity, which implies that any lax policy regime will face a reform movement that will fight inequality of income and wealth and seek to overturn the lax policy regime. Somce democratic societies already have constitutions that contain provisions to enable such challenge to an existing regime, and a mechanism for such transfer of power. Throughout history, most constitutions of democratic societies have erected institutions that enabled the people to restrain the power of the rich and prevent inequality from reaching those levles, but this is not the case with the American constitution. It does not include a legal mechanism that enables the poor from automatically preventing inequality from reaching implausible levels or for the rich to prevent the poor from expropriating the wealth of the rich (see Sitaraman (2017)).

C. Rising market power depresses investment and capital employed. Figures 2.2a and 2.2b trace the effect of the changing market power on capital and investment under the two alternative policy regimes. The figures are drawn in the same scale to highlight the difference between the row policy regimes. Each experiment is conducted under the assumption of a fixed policy regime and utilizes the same sequence of exogenous ζ_t shocks, consequently, the difference between the two is not only in the implied endogenous variables and their dynamics as seen in the figure, but also in the steady states of the two models.



The first important result is that *rising market power suppresses capital investment and falling market power revitalizes it.* This result is the dynamic analogous to the steady state comparisons conducted mathematically earlier, but they show that the steady state comparisons is only part of the story. Within each dynamical system described by Figures 2.2a and 2.2b *the steady state is fixed*, yet the effect of changing market power continues to impact capital invested dynamically at any moment of time. I show later this same result holds with respect to all the macroeconomic variables studied in the comparison of the steady states. But, as will be seen later, the dynamic story is even richer.



The second important result is that the two policy regimes have sharply different impact on the behavior of investment. This difference has two parts. One is the *level*[4] of capital, which is much smaller under the lax policy, with a steady state value of 0.84, compared with 1.25 under the active policy. The second is the percent variability of the capital stock which is greater under the lax policy, where it ranges from 0.45 to 1.19, compared with the stability of that level under the active policy where is ranges from 1.03 to 1.39. Since changed policy regime causes an unexpected change in the steady state, the difference in behavior in Figures 2.2a and 2.2b entails both a jumpt discontinuity at the first date, that reflects the difference in steady states as well as difference in response to changed market power over time.

D. Rising market power depresses capital/output ratio and all other macroeconomic aggregates. The study of investment is representative of all other macroeconomic aggregates, namely output, consumption and labor input. However, in addition, it also depresses the capital/output ration which means it depresses capital invetment more than output. I draw in Figure 2.3 the time evolution of these four variables[5] together with $\mathcal{P}$, but this time I use an alternate random sequence of ζ_t, which results in a sequence of $\mathcal{P}_t$ which is different from the sequence used in Figures 2.1-2.2. Figure 2.3 is drawn for the lax, laissez faire, policy regime and I do not draw the figure for the active regime. It looks similar to the flattened curves in 2.2b.

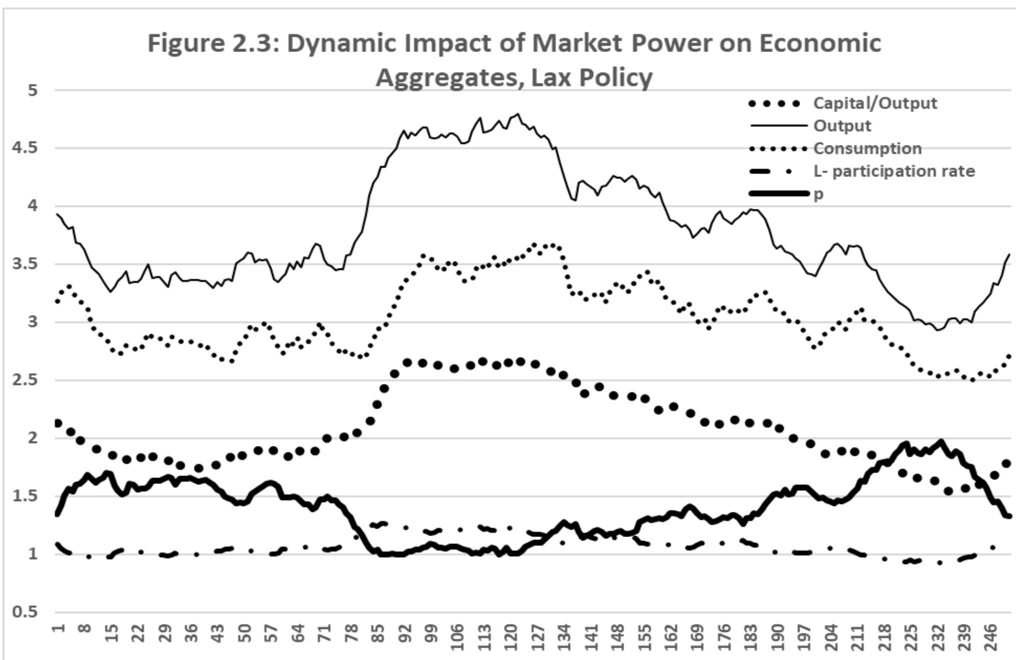


Figure 2.3 together with Figures 2.2a-2.2b show that even within a fixed policy regime, where there is no

[4] All equilibrium aggregates are normalized variables that result from division by trend growth, therefore only *percent differences in their value has unambigous meaning.* In some figures I change their units in order to make it easier to compare their behavior over time.

[5] In Figure 2.3 I scaled up the units of output and consumption by a factor of 10 and labor participation by a factor of 4. This scaling makes it easier to see that all are responding to market power in the same way.

change in steady state, all macroeconomic variables are depressed over time by rising market power and are envigorated to rise higher over time by a decline in market power. This is a full dynamic generalization of the steady state comparisons of Propositions 2.2-2.3 proved earlier.

<u>E. Rising market power depresses the interest rate.</u> The effect on the interest rate is the most surprising result of this dynamic study. Recall that by (2.18b), in steady state the interest rate equals $(g^{-\sigma}/\beta)-1$ and therefore changes in market power do not have any effect on it. This conclusion does not hold in a dynamic setting *when the economy is far away from steady state.* I present the interest rate and the markup in Figure 2.4 which, again, is a simulation for 250 dates. Yet, I find that even within a fixed policy regime, rising market power depresses the interest rate and falling market power inreases the real rate.

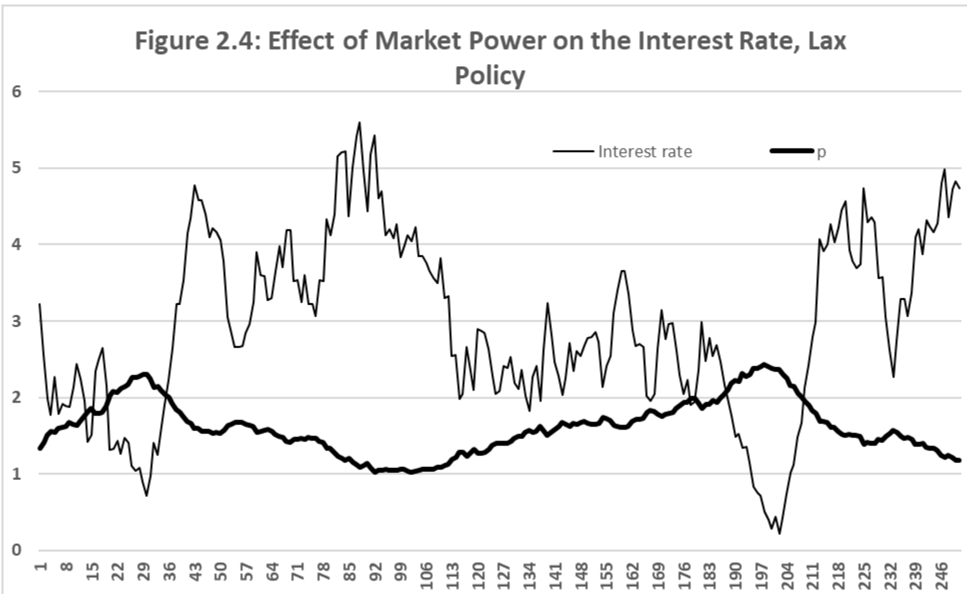


Figure 2.4: Effect of Market Power on the Interest Rate, Lax Policy

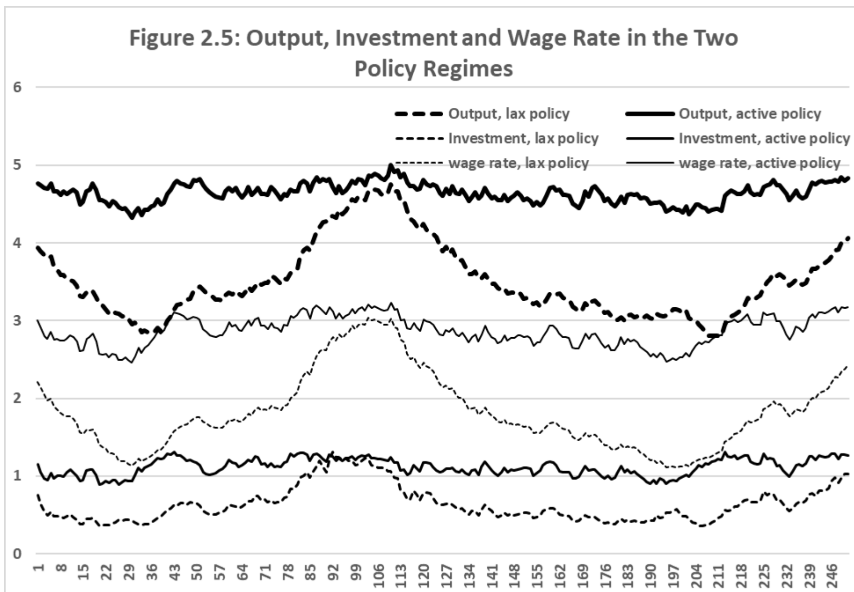
To understand the behavior of the interest rate, note that it responds to changes in the two state variables $(\zeta_t, \mathcal{P}_t)$. Higher ζ_t increases both the interest rate and market power at date t but, in turn, a rise in market power decreases the interest rate, suggesting the net effect on the interest rate is ambigous. But, as explained earlier, changing one ζ_t has a small effect, and the real effect on market power and the interest rate are *runs* of ζ_t. That is, individual ζ_t has amll effect on $\mathcal{P}_t$ and ambigous effect on interest rate but away from steady state, runs of ζ_t move both $\mathcal{P}_t$ and the interest rate. To see this mechanism at work, note that in Figure 2.4 the direction of change in the interest rate is determined not by the level of $\mathcal{P}_t$ but by the *speed at which it either rises or falls*. From date 1 to date 29 $\mathcal{P}_t$ rises fast, causing the interest rate to decline, and from date 29 to date 43 the value of $\mathcal{P}_t$ declines fast, causing the interest rate to rise rapidly. However, from date 113 to date 183 $\mathcal{P}_t$ rises very slowly, causing the interest rate to remain within a fixed range but not rise.

Figure 2.4 offers a hint as to the difference in the dynamics of the interest rate between the two policy regimes where the lax, laissez faire, policy regime results in higher volatility of the rate. Under the active policy regime the interest rate fluctuates mostly between 2% and 4% while under the lax policy regime it ranges from 0.2% to 5.2%.

It is obvious that important economic events like recessions or rapid expansions occur away from steady state, and the behavior of the interest rate is a strong demonstration that forecasting the evolution of endogenous variables away from steady state is very complex problem.

away from steady state is a most significant demonstration of the complexity of forecasting endogenous variables which are far away predictability of endogeo dynamic behavio

2.5.4 Effect of changes in policy regime



2.5.5 Effect of preferences on participation rate

2.3 Other Macroeconomic Effects

2.3.1 Effects on the gap between wages and output per hour

Turning to the relation between the real wage W_t/P_t and output per hour Y_t/L_t, I note first that under pure competition, labor share is $(1-\alpha)$, equilibrium real wage is $[(1-\alpha)Y_t]/L_t$ and output per man-hour is Y_t/L_t; hence, their ratio is a constant $(1-\alpha)$. Hence, if one sets up two series of index numbers, one for the real wage and a second for output per man-hour, with a common value at some date, the two series would be equal without any gap between the two indices. In a random set up the real wage would be highly correlated with output per man-hour.

In an economy with monopoly power this constant ratio does not hold, with the size of the deviation increasing with the level of monopoly power in the economy. By (2.11c)

$$\frac{Y_t}{L_t} = \zeta_t\left(\frac{K_t}{A_t L_t}\right)^{\alpha} \quad , \quad W_t = \frac{(\theta_t - 1)}{\theta_t}(1-\alpha)\zeta_t\varphi_t\left(\frac{K_t}{A_t N_t}\right)^{\alpha}$$

hence, one can see that

$$\frac{W_t}{Y_t/L_t} = \frac{(\theta_t - 1)}{\theta_t}(1-\alpha).$$

If market power rises, or $(\theta_t - 1)/\theta_t$ declines, the *wage declines relative to average labor productivity*. If one selects an earlier date t_0 when there is no market power and labor share is $(1-\alpha)$, creating an index $W_{t_0} = Y_{t_0}/L_{t_0} = 100$ eliminates $(1-\alpha)$. All subsequent differences between the two series would be due to the fluctuations of market power measured by $\mathcal{P}_t = \theta_t/(\theta_t - 1)$. An increase in market power thus *explains why the mean wage has fallen substantially lower than output per man-hour since the late 1970s.*

References

Aghion, P. and Howitt, P. (1992). A Model of Growth through Creative Destruction. *Econometrica* **60**, 323-351.

Aghion, P., Akcigit, U., Howitt, P. (2014). What Do We Learn From Schumpeterian Growth Theory? In: Philippe Aghion and Steven Durlauf (ed.), *Handbook of Economic Growth* **2**, edition 1, 515-563 Amsterdam: Elsevier.

Acemoglu, D. and Restrepo, P. (2019). Robots and jobs: evidence from US labor markets. Working Paper, MIT March.

Acemoglu, D., U. Akcigit, N. Bloom, and W. Kerr. (2012). Innovation, Reallocation and Growth. University of Pennsylvania mimeo.

Akerlof, G. A. and Yellen, J. L. (1985). A Near-Rational Model of the Business Cycle, With Wage and Price Inertia. *The Quarterly Journal of Economics* **100**, Supplement, 823-838.

Aumann, R. J. and M. Kurz (1977). Power and Taxes. *Econometrica* **45**, No. 5, 1137-1161.

Arrow, K.J. and Kurz, M. (1970). *Public investment, the rate of return and optimal fiscal policy*. Baltimore: The John Hopkins Press.

Autor, D., D. Dorn, L. F. Katz, C. Patterson, and J. Van Reenen (2019) The Fall of the Labor Share and the Rise of Superstar firms. MIT mimeo updated from the NBER Working Paper.

Bain, J. (1956). *Barriers to New Competition*. Cambridge Mass: Harvard University Press.

Bank of France data files at http://www.longtermproductivity.com/about.html for 1890-2017.

Barkai, S. (2016): "Declining Labor and Capital Shares." Stigler Center for the Study of the Economy and the State New Working Paper Series.

Bewley, T. (1999). *Why wages don't fall during a recession.* Cambridge, MA: Harvard University Press.

Bresnahan, T. F. and M. Trajtenbergb (1995). General purpose technologies"engines of growth?" *Journal of Econometrics* **65**, 83-108.

Bergeaud, A., G. Cette, and R. Lecat (2016). Productivity Trends in Advanced Countries between 1890 and 2012. *Review of Income and Wealth* **62**(3), 420–444.

Chamley, C. (1986). Optimal taxation of capital income in general equilibrium with infinite lives. *Econometrica* **54**, 607–622.

Chen, C. and O. L. Mangasarian (1996). A class of smoothing functions for nonlinear and mixed complementarity problems. *Computational Optimization and Applications* **5**, 97–138.

Cobb, C. W. and P.H. Douglas (1928). A Theory of Production. *American Economic Review* **18**, (Supplement), 139–165.

Comin, D. and B. Hobijn (2010). An exploration of technology diffusion. *American Economic Review* **100**, 2031-2059.

Comin, D. and M. Mestieri (2014). Technology Diffusion: Measurement, Causes and Consequences. In P. Aghion and S. Durlauf (ed.), *Handbook of Economic Growth*, Chapter 8, 565-622. Amsterdam: Elsevier.

Cunningham, C., F. Ederer and S. Ma (2019). Killer acquisitions. *Available at SSRN 3241707*.

Diamond, P. and E. Saez (2011). The case for progressive taxation: from basic research to policy recommendations. Journal of Economic Perspective 25, no 4, 165-190.

Elsby, M.W.L., M. Hobijn and A. Sahin (2013). The Decline of the U.S. Labor Share. *Brookings Panel on Economic Activity* (September), 1-52.

Federal Reserve Bank of San Francisco data set for 1947-2019 at https://www.frbsf.org/economic-research/indicators-data/total-factor-productivity-tfp/

Foster, L., Haltiwanger, J. and Syverson, C. (2008). Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability? *American Economic Review* **98**, 394–425.

Garcia-Macia, D., Hsieh, C.T. and Klenow, P.J. (2019). How destructive is innovation? *Econometrica* **87**, 1507-1541.

Grossman, G.M. and Helpman, E. (1991). *Innovation and growth in the global economy*. Cambridge: MIT Press, MA.

Grossman, S.J. and Stiglitz, J.E. (1980). On the Impossibility of Informationally Efficient Markets. *The American Economic Review* **70**, 393-408

Gilbert, R. and Newberry, D. (1982). Preemptive Patenting and the Persistence of Monopoly. *American Economic Review* **72**, 514-526.

Greif, A. (2006). *Institutions and the Path to the Modern Economy: Lessons from Medieval Trade.* Cambridge: Cambridge University Press.

Grullon, G., Larkin, Y. and Michaely, R. (2016). Are U.S. Industries Becoming More Concentrated. Working Paper, Rice University.

Gutiérrez, G. and Philippon, T. (2016). Investment-less growth: An empirical investigation. NBER Working Paper 22897.

Gutierrez, G. and T. Philippon (2017b). Declining Competition and Investment in the U.S. NBER Working Paper No. 23583.

Gutierrez, G. and T. Philippon (2018). How EU markets became more competitive than US markets. NBER

Working Paper 24700.

Gutierrez, G. and T. Philippon (2019). The Failure of Free Entry. Working Paper, NYU

Hall, R. E. (2001). The Stock Market and Capital Accumulation. *American Economic Review* **91**, 1185-1202.

Hall, R. (2003). Corporate Earnings Track the Competitive Benchmark. NBER Working paper 10150.

Johns, A. (2009). *Piracy The Intellectual Property Wars from Gutenberg to Gates*. Chicago: The University of Chicago Press.

Jones, C. I. (1995a). Time series test of endogenous growth models. *Quarterly Journal of Economics* **110**, 495-525.

Jones, C. I. (1995b). R&D-based models of economic growth. *The Journal of Political Economy* **103**, 759-784.

Judd, K. L. (1985). Redistributive taxation in a simple perfect foresight model. *Journal of Public Economics* **28**, 59–83.

Kaldor, N. (1961). Capital Accumulation and Economic Growth. In Lutz & Hague (ed.) *The Theory of Capital*, McMillan: London.

Karabarbounis, L. and B. Neiman (2013). The Global Decline of the Labor Share. *Quarterly Journal of Economics* **129**, 61-103.

Keynes, J. M. (1939). Relative Movements of Real Wages and Output. *The Economic Journal*, **49**, Issue 193, 34-51.

King, R.G. and S.T. Rebelo (1999). Resuscitating real business cycles. Chapter 14 in Taylor J.B and M. Woodford (ed.) *Handbook of macroeconomics Volume 1B*. Amsterdam: Elsevier North Holland.

Klette, T. and Kortum, S. (2004). Innovating Firms and Aggregate Innovation. *Journal of Political Economy* **112**, 986-1018.

Kline, P., N. Petkova, H. Williams, and O. Zidar (2019). Who profits from patents? Rent-sharing at innovative firms. *The Quarterly Journal of Economics* **134**, 1343–1404.

Krueger, A. (2017). “The Rigged Labor Market.” *Milken Institute Review*, April.

Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review* **45**, 1-28.

Lawrence, R. (2015). Recent Declines in Labor's Share in U.S. Income: A Preliminary Neoclassical Account. NBER Working Paper No. 21296.

Lentz, R. and Mortensen, D. (2008). An Empirical Model of Growth through Product Innovation. *Econometrica* **76**, 1317-1373.

Lin, J. (1995). The Needham Puzzle: Why the Industrial Revolution Did Not Originate in China. *Economic Development and Cultural Change* **43**, 269–292.

Liu, Y. and Chunjiang L. (2007). Diagnosing The Cause of Scientific Standstill, Unraveling The Needham Puzzle. *China Economist* **10**, 83–96.

Mankiw, N.G.(ed.) and D. Romer (ed.) (1991). *New Keynesian economics volume 2: coordination failure and real rigidities*. Cambridge Mass: The MIT Press.

Mirrlees, J. A. (1971). An exploration in the theory of optimal income taxation. *Review of Economic Studies* **38**, 175-208.

Moylan, C. E. (2008). Employee Stock Options and the National Economic Accounts. *Survey of Current Business*, February, 7-13.

Oberfeld, E. and D. Raval (2014). Micro Data and Macro Technology. Working Paper, Princeton University.

Philippon, T. (2019). *The Great Reversal: How America Gave Up on Free Markets*. Cambridge: The Balkap Press of Harvard University.

Piketty, T. and Saez, E. (2003). Income Inequality in the United States, 1913–1998. *Quarterly Journal of Economics* **118**, 1–39.

Piketty, T. (2014). *Capital in the Twenty-First Century.* Cambridge, MA: Harvard University Press.

Piketty, T. and Zucman, G. (2014). Capital is back: wealth-income ratios in rich countries 1700 - 2010. *Quarterly Journal of Economics* **129**, 1255-1310.

Prescott, E. and Visccher, M. (1977). Sequential location among firms with foresight. *Bell Journal of Economics* **8**, 378 - 393.

Ramsey, F. (1927). A contribution to the theory of taxation. *Economic Journal* **37**, 47-61.

Reinhart, C. M. and K. S. Rogoff (2009). *This Time Is Different: Eight Centuries of Financial Folly.* Princeton: Princeton University Press.

Rognlie, M. (2015). Deciphering the Fall and Rise in the Net Capital Share: Accumulation or Scarcity? *Brookings Papers on Economic Activity* **46**, 1-69.

Romer P. M. (1990). Endogenous technological change. *Journal of Political Economy* **98**, No. 5, Part 2, S71-S102.

Schmalensee, R. (1981). Economics of scale and barriers to entry. *Journal of Political Economy* **89**, 1228-1238.

Saez, E. (2001). Using elasticities to derive optimal income tax rates. *Review of Economic Studies* **68**, 205-229.

Saez, E. and Zucman, G. (2015). Wealth Inequality in the United States Since 1913: Evidence from Capitalized Income Tax Data. UC Berkeley, August 2015.

Salinger, M. (1984). Tobin's q, Unionization, and the Concentration-Profits Relationship." the Rand Journal of Economics **15**, 159-170.

Schumpeter, J. A. (1934). *The theory of economic development: an inquiry into profits, capital, credit, interest, and the business cycle.* Cambridge, MA: Harvard University Press. Translated from the 1911 original German, Theorie der Wirtschaftlichen Entwicklung.

Shy, O. (1995). *Industrial Organization, Theory and Applications*. Cambridge Mss: The MIT Press.

Sitaraman, G. (2017) *The Crisis of the Middle-Class Constitution: Why Economic Inequality Threatens Our Republic*. New York: Alfred A. Knof.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics* **70**, 65–94.

Solow, R. M. (1957). Technical change and the aggregate production function. The review of Economics and Statistics, 312-320.

Solow, R. M. (1960). Investment and technical change. In *Mathematical Studies in the Social Sciences, 1959*, Arrow, K. J., Karlin, S. and Suppes, P. (ed.), Stanford: Stanford University Press.

Solow, R. M. (1979). Another possible source of wage stickiness. *Journal of Macroeconomics* **1**, 79-82.

Spence, M. (1981). The learning curve and competition. *Bell Journal of Economics*, **12**, 49 - 70.

Tirole, J. (1988). *The Theory of Industrial Organization*. Cambridge: The MIT Press.

Tuomala, M. (1990). *Optimal Income Tax and Redistribution.* New York: Oxford University Press.

Tyler, N.S. (2007). Patent non-use and technology suppression: the use of compulsory licensing to promote progress. *University of Pennsylvania Law Review* **162**, 451 - 475.

Wright, S. (2004): "Measures of Stock Market Value and Returns for the US Nonfinancial Corporate Sector, 1900-2002." *Review of Income and Wealth* **50**, 561-584

Wright, G. (2017). World War II, the Cold War, and the Knowledge Economies of the Pacific Coast. Working Paper, Stanford University.

http://www.longtermproductivity.com/about.html