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ABSTRACT

Together with a sense of entering a New Economy, the US experienced in the second half of the 1990s an economic expansion, a stock market boom, a financing boom for new firms and productivity gains. In this paper, we propose an interpretation of these events within a general equilibrium model with financial frictions and decreasing returns to scale in production. We show that the mere prospect of high future productivity growth can generate sizable gains in current productivity, as well as the other above mentioned events.

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Introduction

During the second half of the 1990s, the United States experienced the continuation of one of the longest economic expansions. The distinguishing characteristics of this period can be summarized as follows.

1. High growth rates of output, employment, investment and wages.
2. High growth rates of labor productivity.
3. A stock market boom.
4. A financing boom for new and expanding firms.
5. A sense of moving towards a "New Economy".

In this paper, we propose an interpretation of these events in which the prospect of a New Economy plays a key role in generating the other events. More specifically, we show that the mere prospect of high future productivity growth can generate a stock market boom, a financing boom for new firms, an economic expansion as well as sizable gains in current productivity of labor. There are two main ingredients to our story: financing constraints due to limited contract enforceability and firm-level diminishing returns to scale. Financing constraints generate an endogenous size distribution of firms. Diminishing returns make aggregate productivity dependent on the size distribution of firms. In particular, a more concentrated firm-size distribution results in higher aggregate labor productivity.

In our model, an initial improvement in the prospects for future productivity growth generates the following set of reactions. First, the market value of firms is driven up by the increase in the expected discounted value of profits. Because of the higher market value, new firms find their financing constraints relaxed and are able to operate with a higher initial capital investment and employment. At the aggregate level, the increase in labor demand from the new firms pushes up the wage rate and forces existing unconstrained firms to adjust their production plans to increase the marginal productivity of labor. Therefore, while newer and smaller firms expand their employment, older and larger firms contract over time. This generates a more concentrated economy-wide size distribution of firms. Given the concavity of the production function, the more concentrated firm-size distribution leads to higher aggregate productivity of labor. This "reallocation" effect is in addition to the increase in productivity due to capital deepening. We find that a reasonably calibrated model can generate a cumulative productivity gain of about 2% over a 5 year period, with 1% attributable to the reallocation effect and 1% to capital deepening. This productivity gain is driven solely by the prospects of higher productivity growth and would arise even if the increase in technological growth would never occur.

The theoretical framework consists of a general equilibrium model in which investment projects are carried out by individual entrepreneurs and financed through an optimal contract with investors. The structure of the optimal contract is complicated by limited enforceability: the entrepreneur controls the resources of the firm and can use these resources for his own private benefit. The limited enforceability of contracts implies that new investment projects are initially small, but then increase gradually until they reach the optimal scale. This class of models has shown to be able to explain several important features of firm growth dynamics. See Albuquerque & Hopenhayn (1997), Cooley, Marimon, & Quadrini (2000), Monge (2001) and Quintin (2000).

To keep our analysis focused, we abstract from other channels emphasized in the literature through which expectations may have an immediate impact on current economic activity such as time-to-build, capital adjustment costs, or consumption smoothing. Also, it should be clear that we do not believe that the economic expansion experienced by the U.S. economy during the second half of the 1990s was entirely driven by expectations of future higher productivity growth. Rather, we see our explanation as complementary to the actual improvement in firm level technology which, for simplicity, we omit from the analysis.

Section 1 reviews the main events experienced by the U.S. economy in the 1990s. Section 2 contains an overview of how these facts are linked in our theoretical model and provides the intuition for the main results of the paper. Section 3 presents the model and Section 4 contains the quantitative analysis. Section 5 provides additional empirical evidence in support of the reallocation mechanism described in the paper and Section 6 concludes.

1 Facts about the 1990s

In this section we provide some quantitative evidence about the above-mentioned five characteristics of the US economy during the second half of the 1990s.

Macroeconomic expansion: The second half of the 1990s features the continuation of one of the longest economic expansions in recent US history with an acceleration in the growth rates of output, employment, investment and wages. Figure 1 presents the growth rates of these four aggregates for the period 1990-2000.

Productivity growth: A recent paper by Baily (2002) surveys some of the studies that estimate the sources of productivity growth during the second half of the 1990s. We summarize the estimates in Table 1, where we have averaged across three sets of estimates, namely, updated numbers from Oliner & Sichel (2000), Economic Report of the President (2001) and Jorgenson, Ho, & Stiroh (2001). These numbers incorporate the downward revision of GDP made in the summer of 2001.

Table 1: Decomposition of Growth in Output Per Hour, 1995-2000.

Average annual growth 1995-2000	**2.55**
Average annual growth 1973-1995	**1.40**
Acceleration of growth = 1.15%	
Contribution of labor quality	-0.01
Contribution of MFP in computer-sector	0.31
Contribution of capital deepening	0.43
Contribution of MFP outside computer-sector	0.42

Source: Baily (2002)

Output per hour in the nonfarm private business sector has grown at an annual rate of 2.55% during the period 1995-00 compared to a 1.40% growth rate during the period 1973–95. Therefore, there has been an acceleration of 1.15%. Abstracting from labor quality which counts for a small decline (-0.01%), the table decomposes this acceleration in three components.

The first component is the growth in multifactor productivity (MFP) in the computer sector. The estimate for this is 0.31%. Capital deepening, which results from the investment boom especially in computer equipment, counts for 0.43%. The remaining 0.42% is the structural acceleration in multifactor productivity outside the computer-producing sector.[1] Our analysis will focus on the last component which accounted for somewhat over 2% of cumulative growth during the period 1995-00.[2]

Stock market boom: Equity prices have registered a spectacular increase during the second half of the 1990. During that period the S&P500 or the Dow Jones Industrial indexes have more than doubled. The goal of this paper is to relate this stock market boom to the growth in labor productivity experienced by the U.S. economy during this period. Figure 2 plots the productivity growth and the price-earning ratio in the post-war period. The post-war period can be divided in three sub periods: the "golden age" of rapid productivity growth between 1950:2 and 1972:2, the "slow down period" from 1972:2 to 1995:5, and the "revival period" since 1995:4. The identification and labeling of these three sub-periods are taken from Gordon (2001). Clearly, there is a strong positive association between productivity growth and price-earnings ratios.[3] Although the causal relationship can go in both directions, in this paper we will emphasize the channel going from the asset prices to the productivity of labor.

Financing boom for new firms: Figure 4 illustrates the financing boom for new firms with the evolution of the Nasdaq composite index and the

[1]Gordon (2001) further decomposes this last component into cyclical and structural, arguing that most of the gain is cyclical. Given that such a decomposition depends on additional auxiliary assumptions, we do not distinguish here between these two components although we will distinguish between them in our theoretical framework.

[2]Several studies (see for example Brynjolfsson & Hitt (2000), Jorgenson & Stiroh (2000), Oliner & Sichel (2000)), interpret the multifactor productivity outside the computers sector as the result of the network and externality advantages brought about by information and communication technologies. At the same time, the increase in investment and the subsequent capital deepening was driven by the fall in prices of computers. In this paper we provide a different interpretation of the driving forces underlying the improvement in multifactor productivity and capital deepening.

[3]Because the subdivision in the three sub-periods is to some extent arbitrary, we have also computed the trends of these two series using a low-pass filter. The pattern of these trends displays a similar picture.

amount of venture capital investment. While the association between the value of firms quoted in Nasdaq and venture capital investment is not surprising, it is worth to be emphasized because it shows the close connection between the value that the market attributes to investment projects and the volume of funds injected in those projects. At the beginning of 2000, the size of the venture capital market has reached dimensions of macroeconomic significance. Although these funds were only about 1 percent of GDP, in terms of net private domestic investment they are about 15 percent. Moreover, the funds injected through venture capital are only part of the funds raised and invested by these firms. Some of these firms, in fact, raise funds through IPOs. Even if the percentage of venture capital firms that go public is small (about 10 percent), the funds raised through IPOs are considerable. The number of IPOs also boomed during the second half of 1990s.

"New Economy": While more elusive, the sense of moving towards a New Economy has been manifest in many ways. Shiller (2000) contains a detailed account of this tendency linked, among other things, to the emergence of the internet and the ever wider use of computer technology. Fed chairman Mr. Greenspan has been making the case for an upward shift in trend productivity growth driven by new equipment and management techniques since 1995. See, for example, Ip & Schlesinger (2001). The same article also describes how this view spread across the Federal Open Market Committee: referring to a speech of Fed member Mr. Meyer, the article reports:

> "'*we can confidently say ... that, since 1995, actual productivity growth has increased.' At the time he suggested that he believed the economy could annually grow by overall as much as 3% without inciting inflation, up from his longtime prior estimate of a 2.5% limit. Soon, thereafter, he indicated that perhaps the right number was 3.5% to 4%.*"

The goal of this paper is to link these facts within a unified framework and to provide an explanation for the labor productivity improvement which does not rely on network and spill over effects following the diffusion of information and communication technologies.

2 Overview of the main results

In this section we describe informally the model's main mechanisms that link the events documented above. A detailed analysis of the model will be conducted in the next section.

Suppose that there is a fixed number of workers with a constant supply of labor and a fixed number of firms. All firms run the same decreasing return-to-scale technology $F(L)$ with the input of labor L as plotted in Figure 4. Given the concavity of the production function, there is an optimal input of labor which is determined by the equilibrium wage rate. In the absence of financial constraints, all firms will employ the same input of labor $\overline{L}$. However, if the employment of labor requires capital, the presence of financial constraints may limit the ability of the firm to employ $\overline{L}$. Assume there is a fraction of firms that are financially constrained and operate at a sub-optimal scale, and the remaining fraction includes firms that are not constrained and operate at the optimal scale. For simplicity let's assume that half of the firms are financially constrained and employ $\underline{L}$, and the other half are unconstrained and employ $\overline{L}$. This is shown in panel a) of Figure 4

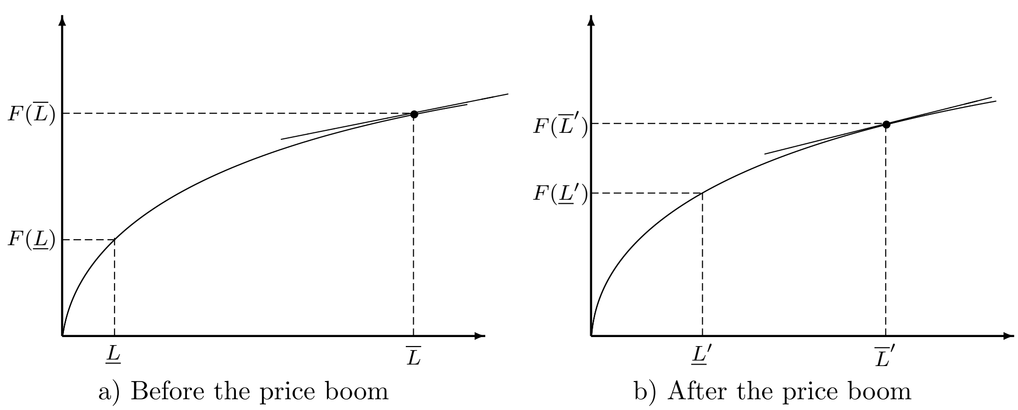

Figure 4: Reallocation of workers and productivity effect.

Because the production function is concave, this allocation of labor is clearly inefficient. By reallocating workers from unconstrained firms to constrained firms as in panel b), aggregate production increases. Because the supply of labor does not change, the productivity of labor also increases.

The main point of the paper is to show that a stock market boom can generate a reallocation of workers similar to the one described above. The idea is that, when the value of a new firm increases, the firm is able to get more initial financing from investors. This, in turn, increases the average employment of constrained firms, which in the above graph is captured by the shift to the right of $\underline{L}$. The increase in the demand of labor coming from constrained firms increases the wage rate which in turn reduces the optimal (unconstrained) input of labor $\overline{L}$. This is captured in the graph by the shift to the left of $\overline{L}$. As a consequence of the increase in the size of constrained firms and the decrease in the size of unconstrained firms, the aggregate productivity of labor increases. Therefore, an asset price boom can generate an economic expansion through a productivity improvement.[4]

In the above example we have made two special assumptions. The first assumption is that labor is perfectly complementary to capital. The relaxation of this assumption may increase the impact of an asset price boom on the productivity of labor. This is because higher wages may induce firms to use more capital per unit of labor (capital deepening). The second assumption was the constancy of the aggregate supply of labor. Although in the full specification of the model we maintain the assumption that the number of workers is fixed, working time depends on the wage rate. The relaxation of this second assumption will weaken the impact of an asset price boom on the productivity of labor. To see this, consider the extreme case in which labor is perfectly elastic. In this case the wage is not affected by the asset price increase and $\overline{L}$ does not change. However, the size of constrained firm $\underline{L}$ will still move to the right. This would imply that the productivity of constrained firms declines while the productivity of unconstrained firms remain unchanged. This may induce a fall, rather than an increase, in the aggregate productivity of labor.[5]

Based on the above considerations, we can summarize below the main

[4]If we were to compute the Solow residuals using a constant return to scale function, $z \cdot L$, applied to aggregate data, the improvement in labor productivity would be interpreted as an exogenous increase in z, rather than generated endogenously by the reallocation of resources. In fact, when labor is the only input of production and the technology is constant return-to-scale, z is the productivity of labor. As we will see later, this interpretation also applies in the case in which there is a second input of production, that is, capital.

[5]The productivity of labor does not necessarily decrease. In fact, even though the productivity of constrained firms decreases, their employment share increases. Consequently, the impact on aggregate productivity depends on whether the decrease in the individual productivity of constrained firms dominates their increase in the share of employment.

factors that affect the productivity improvement:

- **Returns to scale**: If the degree of concavity in the production function is high, the reallocation of labor will have large effects on productivity. In the extreme case in which $F(L)$ is linear, the reallocation of labor has no effect on productivity beyond capital deepening.

- **Size heterogeneity**: If the size of constrained firms is small relative to unconstrained firms, the productivity differential is large. This implies that the reallocation of labor can generate a large productivity gain. The number of constrained firms is obviously also important.

- **Elasticity of labor**: If the elasticity of labor is small, the expansion of constrained firms generates a large increase in the wage rate which in turn induces a large fall in the employment of unconstrained firms. Therefore, the productivity improvement will be higher.

In Section 5 we provide some empirical evidence in support of this reallocation mechanism. Before discussing this empirical evidence, however, we turn now to the description of the whole general equilibrium model.

3 The model

Agents and preferences: The economy is populated by a continuum of agents of total mass 1. In each period, a fraction $1-\alpha$ of them is replaced by newborn agents. Therefore, α is the survival probability. A fraction e of the newborn agents have an investment project and, if they get financing, they become entrepreneurs. The remaining fraction, $1-e$, become workers. Agents maximize:

$$E_0 \sum_{t=0}^{\infty} \left(\frac{\alpha}{1+r}\right)^t \Big(c_t - \varphi_t(h_t)\Big) \tag{1}$$

where r is the intertemporal discount rate, c_t is consumption, h_t are working hours, $\varphi_t(h_t)$ is the disutility from working. We assume that the disutility from working is time dependent as explained below.

Utility flows are discounted by $\alpha/(1+r)$ as agents survive to the next period only with probability α. Given the assumption of risk neutrality, r will be the risk-free interest rate earned on assets deposited in a financial intermediary.[6] The function φ_t is strictly convex and satisfies $\varphi_t(0) = 0$. Denoting by w_t the wage rate, the supply of labor is determined by the condition $\varphi_t'(h_t) = w_t\alpha/(1+r)$. The wage rate is discounted because wages are paid in the next period as specified below. For entrepreneurs $h_t = 0$ and their utility depends only on consumption.

Investment project: An investment project requires an initial fixed investment κ_t, which is sunk, and generates revenues according to:

$$y_t = z_t \cdot F(k_t, l_t)^\theta \tag{2}$$

where y_t is the revenue generated at time t given the inputs of capital k_t and labor l_t. The variable z_t is the same for all firms and we will refer to this variable as the "aggregate technology level". The function F is strictly increasing with respect to each of the two arguments and homogeneous of degree 1. The parameter θ is smaller than 1, and therefore, the revenue function displays decreasing returns to scale. Capital depreciates at rate δ.

With probability $1-\phi$ the project becomes unproductive. Therefore, there are two circumstances in which the firm is liquidated: When the entrepreneur dies and when the project becomes unproductive. The survival probability is $\alpha\phi$. To simplify the analysis we assume that the carrier choice of an agent with entrepreneurial skills is irreversible. Hence, if the firm gets liquidated, the entrepreneur remains inactive. We allow the liquidation probability ϕ to change stochastically to capture the age dependence of the firm survival. The precise nature of the stochastic process for ϕ will be specified in the calibration section.

The total resources available after production, net of wages, are $(1-\delta)k_t + z_tF(k_t,l_t)^\theta - w_tl_t$. Using the optimality condition for the input of labor, we can express l_t as a function of z_t, k_t and w_t, that is, $l(z_t,k_t,w_t)$. We can then express the firm's resources as $R(z_t,k_t,w_t) = (1-\delta)k_t + z_tF(k_t, l(z_t,k_t,w_t))^\theta - w_tl(z_t,k_t,w_t)$.

Financial contract and repudiation: To finance a new project the entrepreneur enters into a contractual relationship with one or more investors.

[6] On each unit of assets deposited in a financial intermediary, agents receive $(1+r)/\alpha$ if they survive to the next period and zero otherwise. The financial intermediary acts as a life-insurance company and the expected return on these deposits is r.

The financial contract is not fully enforceable.[7] At the end of the period, the entrepreneur has the ability to divert the firm resources (capital and labor) to generate a private return according to the function:

$$D(z_t, k_t, w_t) = \lambda \cdot z_t \cdot F(k_t, l_t(z_t, k_t, w_t))^\theta = \lambda \cdot y_{t+1} \tag{3}$$

In this case the firm becomes unproductive and capital fully depreciates. The fact that the firm becomes unproductive in case of diversion makes the issue of renegotiation irrelevant (the production capacity is lost). Notice that λ is allowed to be larger than 1. In fact, even if λ is moderately greater than 1, diversion is still inefficient. This is because to generate a one-time return from diversion, the ability of the firm to generate profits is permanently lost. Moreover, in case of diversion capital fully depreciates.

This specification captures the notion that the default value is closely related to the size and productivity of the project under control of the entrepreneur. Other specifications would be possible, for instance we could have used $\lambda \cdot k$. While the model would have had similar properties, our specification is more convenient because all firms will choose the same capital-labor ratio independently of the production scale. This property simplifies the decomposition of the productivity gains between capital deepening and labor reallocation as we will see in the quantitative section.

Aggregate technology level and balanced growth path: The aggregate technology level z_t grows over time at rate g_z. We assume that the growth rate can take two values, g_z^L and g_z^H, with $g_z^L < g_z^H$. The economy can switch from one growth regime to the other with some probability p_t. This probability is itself stochastic and the next period value is drawn from the probability distribution $\Gamma(p'|p, g_z')$. This distribution depends on the current p and the next period growth regime g_z'. The growth rate g_z and the switching probability p—which we denote by $x \equiv (g_z, p)$—are the aggregate shocks in the model. The stochastic distribution of x (joint distribution of g_z and p) is derived from the distribution function $\Gamma(p'|p, g')$.

The growth in the aggregate level of technology z_t allows the economy to experience unbounded growth. To insure stationarity around some trend, we need to make particular assumptions about the disutility from working,

[7] The paper is related to the literature on optimal contracting with limited enforceability as in Albuquerque & Hopenhayn (1997), Alvarez & Jermann (2000), Cooley et al. (2000), Kehoe & Levine (1993), Marcet & Marimon (1992), Monge (2001), Quintin (2000).

$\varphi_t(h)$, and the initial set up investment of a new firm, κ_t. Define $1 + g_t = (1 + g_{z,t})^{\frac{1}{1-\theta\epsilon}}$ where the parameter ϵ is the capital share parameter in the function $F(k, l) = k^{\epsilon} l^{1-\epsilon}$. Moreover, define $A_t = \prod_{j=1}^{t}(1 + g_j)$. We assume that the disutility from working takes the form $\varphi_t(h) = \pi A_t h^{\nu}$. This particular specification can be justified by interpreting the disutility from working as the loss in home production where the production technology evolves similarly to the market technology. Regarding the set up investment of a new firm we assume that it takes the form $\kappa_t = A_t \kappa$. Given these specifications of the disutility from working and the set up investment, the economy will fluctuate around the stochastic trend A_t. Therefore, all the endogenous variables with unbounded growth will be detrended by the factor A_t.

Stock market value: Before characterizing the properties of the contract, let's define here the market value of a firm. If the firm is not liquidated, it will pay the dividend $R(z_{t-1}, k_{t-1}, w_{t-1}) - k_t$, where k_{t-1} was the capital invested in the previous period and k_t is the capital invested this period. If the firm is liquidated, there is not capital investment and the dividend is $R(z_{t-1}, k_{t-1}, w_{t-1})$.

The (non-detrended) market value of the firm, denoted by P_t, is the discounted value of the firm's dividends, that is,

$$P_t = \left(\frac{1}{1+r}\right) E_t \sum_{j=t}^{\infty} \left(\prod_{s=t}^{j-1} \beta_s\right) \Big[R(z_j, k_j, w_j) - \alpha\phi_t k_{j+1}\Big] \tag{4}$$

where $\beta_s = \alpha\phi_s/(1 + r)$. Notice that the capital investment is multiplied by the survival probability $\alpha\phi_s$ because in case of liquidation next period capital is zero. After some rearrangement and dividing the whole expression by A_t, this can be expressed as:

$$P_t = k_t + E_t \sum_{j=t}^{\infty} \left(\prod_{s=t}^{j-1} \beta_s (1 + g_{s+1})\right) \left[-k_j + \left(\frac{1}{1+r}\right) R(k_j, w_j)\right] \tag{5}$$

where now all the variables are detrended.

Notice that, although the detrended payments do not display unbounded growth, the detrended value of the firm depends on the expected future growth rates of the economy: if the economy is expected to grow faster, future payments will also grow at a higher rate. This, in turn, increases the value of the firm today, as shown in Equation 5.

Timing summary: Before starting the analysis of the model, we summarize here its timing. All the shocks are realized at the beginning of the period. Therefore, agents' death, firms' death, next period survival probability, level of technology z (for the new investment), and switching probability become known at the beginning of the period. Firms enter the period with resources $z_{t-1}F(k_{t-1}, l_{t-1})^{\theta} + (1-\delta)\, k_{t-1}$. These resources are used to pay for the wages of the workers hired in the previous period and to finance the new capital investment (if still productive). What is left is paid as dividends. At this stage the firm also decides the new input of labor. It is at this point that the entrepreneur decides whether to repudiate the contract and divert the resources of the firm (capital and labor). Therefore, the choice to default is made before observing the next period value of z. This timing convention is convenient for the characterization of the optimal contract. Finally, it is important to re-emphasize the timing of the level of technology z. Production depends on the current z which is known at the moment of choosing the inputs of capital and labor. Therefore, there is not uncertainty about the return from current investment. Only the returns from future investments are uncertain.

3.1 The economy with enforceable contracts

We first characterize allocations when contracts are fully enforceable and the entrepreneur is unable to divert the firm's resources. In this case, all firms will employ the same input of capital $\bar{k}$ which is given by:

$$\bar{k} = \arg\max_{k} \left\{ -k + \left(\frac{1}{1+r}\right) R(k, w) \right\} \tag{6}$$

In this simple economy the detrended wage is constant because there is a constant number of firms (entrepreneurs) and the disutility from working grows at the same rate of the whole economy.

Using equation (5), the detrended market value of the firm is:

$$P_t = \bar{k} + E_t \sum_{j=t}^{\infty} \left(\prod_{s=t}^{j-1} \beta_s (1 + g_{s+1}) \right) \left[-\bar{k} + \left(\frac{1}{1+r}\right) R(\bar{k}, w) \right] \tag{7}$$

When a new firm is created, the value P_t is shared between the investor and the entrepreneur. In the case of competitive financial markets, the investor will get the cost of creating the new firm, $\kappa + \bar{k}$, and the entrepreneur will get $P_t - \kappa - \bar{k}$.

The probability of a regime switch p_t affects the value of a firm (because it affects the probability distribution of future $g's$), but it is completely neutral with respect to the real variables of the economy. Therefore, a change in likelihood of a regime switch does not have any real effect unless this switch takes place. In contrast, we will see in the next section that when contracts are not fully enforceable, p_t affects not only the value of the firm but also production decisions and the aggregate productivity of labor.

3.2 The economy with limited enforceability

A contract specifies the payments to the entrepreneur, c_t, the payment to the investor, τ_t, and the capital investment, k_t, for each history realization of the states. We assume that the payments to the entrepreneur cannot be negative. Also denote by q_t the value of the contract for the entrepreneur and by S_t the total surplus. All these variables are detrended by $A_t = \prod_{j=1}^{t}(1+g_j)$. Denote by $\mathbf{s}$ the aggregate states of the economy plus the individual survival probability ϕ. The contractual problem can be written recursively as follows:

$$S(\mathbf{s},q) = \max_{k,c(\mathbf{s}'),q(\mathbf{s}')} \left\{-k+\left(\frac{1}{1+r}\right)R(k,w(\mathbf{s}))+\beta E(1+g')S(\mathbf{s}',q(\mathbf{s}'))\right\} \tag{8}$$

subject to

$$q = \beta E(1+g')\Big[c(\mathbf{s}')+q(\mathbf{s}')\Big] \tag{9}$$

$$q \geq D(k,w(\mathbf{s})) \tag{10}$$

$$c(\mathbf{s}') \geq 0,\ q(\mathbf{s}') \geq 0 \tag{11}$$

The function $S(\mathbf{s},q)$ is the end-of-period surplus of the contract, net of the cost of capital. If we invest k—which is a cost—the discounted gross revenue paid in the next period is $(1/(1+r))R(k,w(\mathbf{s}))$. Therefore, the present value of the firm return is $-k+(1/(1+r))R(k,w(\mathbf{s}))$. The surplus function depends on the aggregate states plus the firm-specific survival probability ϕ—which we have denoted by $\mathbf{s}$—and the endogenous individual state q. Notice that the discount factor $\beta=\alpha\phi/(1+r)$ is known in the current period but changes stochastically over time because it depends on ϕ.

Condition (9) is the promise-keeping constraint, (10) is the enforceability constraint (incentive-compatibility) and (11) imposes the non-negativity of the payments to the entrepreneur. The term $(1+g')$ comes from the detrending procedure and the prime denotes next period variable. In formulating the above problem we take as given the optimal policy when the firm is liquidated. This policy consists of setting consumption and continuation utility equal to zero. This is the optimal policy given that the entrepreneur will permanently loose the ability to run a firm in future periods.

Coherently with the formulation of the surplus function, the aggregate states of the economy are given by the current growth in productivity g, the switching probability p, and the distribution (measure) of firms over ϕ and q. The recursive problem can be solved once we know the distribution function (law of motion) for the aggregate states and the individual survival probability, which we denote by $\mathbf{s}' \sim H(\mathbf{s})$.

Denote by μ the Lagrange multiplier associated with the promise-keeping constraint (9) and denote by γ the Lagrange multiplier associated with the enforceability constraint (10). Conditional on the survival of the firm, the first order conditions are:

$$\left(\frac{1}{1+r}\right) R_k - 1 - \gamma D_k \;=\; 0 \tag{12}$$

$$\mu(\mathbf{s}') + \gamma - \mu \;=\; 0 \qquad\qquad \text{for all } \mathbf{s}' \tag{13}$$

$$\mu - \gamma \geq\; 0, \qquad\qquad (= \text{if } c(\mathbf{s}') > 0) \tag{14}$$

$$\beta E(1+g')\Big[c(\mathbf{s}') + q(\mathbf{s}')\Big] - q = 0 \tag{15}$$

$$q - D(k, w(\mathbf{s})) \geq 0 \qquad\qquad (= \text{if } \gamma > 0) \tag{16}$$

Condition (14), combined with condition (13), implies that the payment to the entrepreneur $c(\mathbf{s}')$ is zero if the next period Lagrange multiplier $\mu(\mathbf{s}')$ is greater than 0. This has a simple intuition. Because μ decreases when the enforceability constraint is binding (see condition (13)), when $\mu(\mathbf{s}')$ reaches the value of 0, the enforceability constraint will not be binding in future periods, that is, $\gamma = 0$ for all possible realizations of $\mathbf{s}'$. In this case the firm will always employ the optimal input of capital $\bar{k}(\mathbf{s})$ as can be verified in (12). Therefore, when $\mu(\mathbf{s}') = 0$, the firm is unconstrained.

Before reaching the unconstrained status, however, the enforceability constraint (10) can be binding in future periods and γ is greater than zero in some contingencies. This implies that the firm will employ a sub-optimal input of capital. Moreover, in those periods in which the enforceability constraint is binding, condition (16) is satisfied with equality (and zero payments to the entrepreneur, unless the unconstrained status is reached that period). Therefore, this condition will determine the growth pattern of the firm. The following proposition states these properties more formally.

Proposition 3.1 *There exists $\overline{q}(\mathbf{s})$ such that,*

(a) The function $S(\mathbf{s}, q)$ is increasing and concave in $q \leq \overline{q}(\mathbf{s})$.

(b) Capital input is the minimum between $k = D^{-1}(q, w(\mathbf{s}))$ and $\bar{k}(\mathbf{s})$.

(c) If $q \leq \beta E(1 + g')\overline{q}(\mathbf{s}')$, the entrepreneur's payment $c(\mathbf{s}')$ is zero.

(d) If $q > \beta E(1 + g')\overline{q}(\mathbf{s}')$, there are multiple solutions to $c(\mathbf{s}')$.

Proof 3.1 *The recursive problem (8) is a contraction. Therefore, there exists a unique function $S(\mathbf{s}, q)$ that satisfies the Bellman equation. Moreover, the recursion preserves concavity which guarantees the concavity of the surplus function. The other properties derive directly from the first order conditions (12)-(16).* *Q.E.D.*

Therefore, the dynamics of the firm has a simply structure. The promised value and the input of capital grow on average until the entrepreneur's value reaches $\overline{q}(\mathbf{s})$. At this point the input of capital is always kept at the optimal level $\bar{k}(\mathbf{s})$ and the total value of the firm, after capital investment, is $P(\mathbf{s}) = \bar{k}(\mathbf{s}) + S(\mathbf{s}, \overline{q}(\mathbf{s}))$.

3.2.1 Initial conditions

After characterizing the surplus function, we can now derive the initial conditions of the contract. Assuming competition in financial markets, the initial contract solves:

$$\begin{aligned} q^0(\mathbf{s}) \;&=\; \max \;\; q \\ \text{s.t.} \;\; S(\mathbf{s}, q) - q \;&\geq\; \kappa \end{aligned} \tag{17}$$

This problem maximizes the value of the contract for the entrepreneur, q, subject to the participation constraint for the investor, $S(\mathbf{s}, q) - q \geq \kappa$. The solution to this problem is unique. In fact, the function $S(\mathbf{s}, q)$ is increasing and concave, and for $q \geq \overline{q}(\mathbf{s})$ its slope is zero. Therefore, above some q, the function $S(\mathbf{s}, q) - q$ is strictly decreasing in q. This implies that the solution is unique and satisfies the zero-profit condition $S(\mathbf{s}, q) - q = \kappa$.

The determination of the initial value of q is shown in Figure 5. This figure plots the value of the contract for the investor, $S(\mathbf{s}, q) - q$, as a function of q. The initial value of q—and therefore, the initial input of capital—is given by the point in which the curve crosses the set up investment κ.

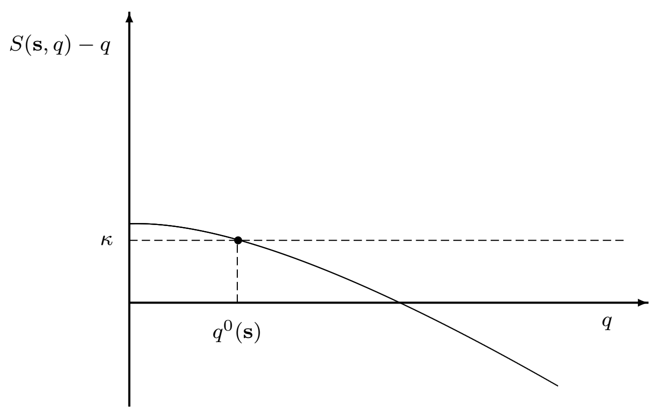

Figure 5: Initial conditions of the optimal contract.

3.2.2 General equilibrium

We provide here the definition of a recursive general equilibrium. The sufficient set of aggregate states are given by the current growth rate g, the switching probability p, and the distribution (measure) of firms over ϕ and q, denoted by M. We have denoted the aggregate states plus the individual survival probability by $\mathbf{s} = (g, p, M, \phi)$.

Definition 3.1 (Recursive equilibrium) *A recursive competitive equilibrium is defined as a set of functions for (i) consumption $c(\mathbf{s})$ and working hours $h(\mathbf{s})$ from workers; (ii) contract surplus $S(\mathbf{s}, q)$, investment $k(\mathbf{s}, q)$,* *consumption* $c(\mathbf{s}, q)(\mathbf{s}')$ *and wealth evolution* $q(\mathbf{s}, q)(\mathbf{s}')$ *for entrepreneurs; (iii) initial condition for a new firm* $q^0(\mathbf{s})$*; (iv) wage* $w(\mathbf{s})$*; (v) aggregate demand of labor from firms and aggregate supply from workers; (vi) aggregate investment from firms and aggregate savings from workers and entrepreneurs; (vii) distribution function (law of motion)* $\mathbf{s}' \sim H(\mathbf{s})$*. Such that: (i) the household's decisions are optimal; (ii) entrepreneur's investment, consumption and wealth evolution satisfy the optimality conditions of the financial contract (conditions (12)-(16)), and the surplus satisfies the Bellman's equation (8); (iii) the wage is the equilibrium clearing price in the labor market; (iv) the capital market clears (investment equals savings); (v) the law of motion* $H(\mathbf{s})$ *is consistent with the individual decisions and the stochastic process for* $x = (g, p)$ *and* ϕ*.*

3.2.3 The impact of an asset price increase

We now consider the consequences of an increase in the value of new firms brought about by an increase in the probability that the economy will be in the high growth regime. We will state this experiment more precisely in our quantitative analysis. For the purpose of this section, any exogenous increase in the value of new firms would have similar consequences.

Figure 6 plots the value of the contract for the investor (before investing). As in the previous Figure 5, the initial value of q is at the point in which the investor's value crosses the set up investment κ. The second and higher curve follows from the increase in the value or surplus of the firm. The new investor's value intersects κ at a higher level of q. Because higher values of q are associated with higher values of k (remember that for constrained firms $q = D(k, w)$), the price change increases the initial investment of new firms. This implies that the total stock of capital and employment increase.

The analysis underlying Figure 6 is based on the assumption that the wage rate remains constant. Although the supply of capital is elastic (given the risk neutrality assumption), the supply of labor is not perfectly elastic. This implies that the increase in the demand of labor induces an increase in the wage rate which reduces, but only partially, the initial increase in the stock of capital and in the demand of labor. The change in the firm-size distribution following such an asset price increase and its consequences for aggregate labor productivity will be the focus of the quantitative analysis in the next section.

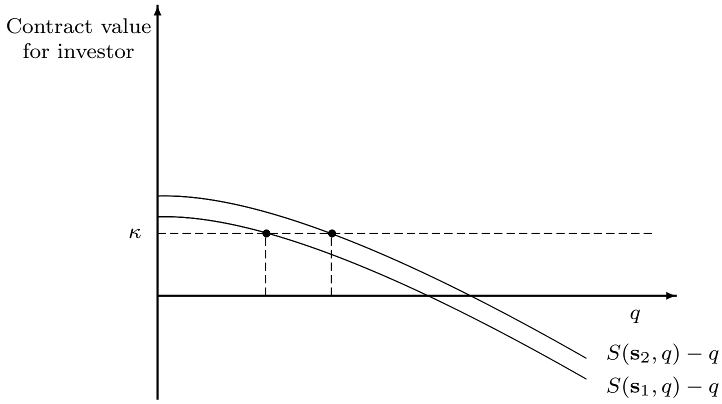

Figure 6: Impact of an asset price increase on the initial conditions of the contract.

4 Quantitative analysis

In this section we calibrate the model and study how expectations of persistent higher future growth rates—the New Economy—impact on the macro performance of the economy.

Calibration of shock process and simulated experiment: Our objective is to study a sequence of events where after a long period of slow growth, the economy experiences an increase in the probability of higher future growth rates of technology. Assuming that the high growth regime will not be realized for several periods (although the probability of high growth persists), we will focus on a pure expectational shock which we interpret as the prospects of a New Economy.

The growth rate g_z was assumed to take two values, g_z^L and g_z^H. We now assume that the switching probability p also takes two values. The first value is zero and the second is denoted by $\overline{p}$. Given that p takes only two values, there are four possible shock realizations: $x_1 = (g_z^L, 0)$, $x_2 = (g_z^L, \overline{p})$, $x_3 = (g_z^H, 0)$, $x_4 = (g_z^H, \overline{p})$. The stochastic properties of these shocks are governed by a four-dimension transition probability matrix. To construct this matrix we make the following assumptions about the distribution $\Gamma(p' \mid p, g_z')$. First, conditional on remaining on the same growth regime, the transition probability matrix for $p \in \{0, \overline{p}\}$ is:

$$\Gamma(p' \mid p, g_z' = g_z) \;=\; \begin{bmatrix} 1-\rho & \rho \\ \rho & 1-\rho \end{bmatrix}$$

If the economy switches to a different growth regime, the transition probability matrix is:

$$\Gamma(p' \mid p, g_z' \neq g_z) \;=\; \begin{bmatrix} 1 & 0 \\ 1 & 0 \end{bmatrix}$$

Therefore, we impose that if the economy switches to a new growth regime, the probability of switching back to the old regime is zero in the first period. This assumption makes a regime switch more persistent.

Using the above specifications, the transition probability matrix for the four states $x = (g_z, p)$ (joint distribution of g_z and p) is equal to:

$$\text{prob}(x'|x) \;=\; \begin{bmatrix} (1-\rho) & \rho & 0 & 0 \\ \rho(1-\overline{p}) & (1-\rho)(1-\overline{p}) & \overline{p} & 0 \\ 0 & 0 & (1-\rho) & \rho \\ \overline{p} & 0 & \rho(1-\overline{p}) & (1-\rho)(1-\overline{p}) \end{bmatrix}$$

This matrix depends only on two parameters: ρ and $\overline{p}$. In our simulation exercise we assume that $\rho \approx 0$ and we consider several values of $\overline{p}$. Given this parameterization, the switching probability $p \in \{0, \overline{p}\}$ is very persistent as long as the economy remains in the same growth regime. We interpret the first state $x_1 = (g_z^L, 0)$ as the state prevailing during the period 1972:2-1995:4 and the second state $x_2 = (g_z^L, \overline{p})$ as the state prevailing during the period 1995:4-2000:4.

Consistent with this interpretation, we take the growth rate in trend productivity during the period 1972:2-1995:5 to calibrate g_z^L. As reported in Table 1, the trend growth in labor productivity during this period was 1.42% per year. Therefore, we set $g^L = (g_z^L)^{1/(1-\theta\epsilon)} = 0.0142$. The value of g_z^H, instead, is interpreted as the potential growth rate in the "New Economy". According to the citation in Ip & Schlesinger (2001), the New Economy was believed to grow at rates exceeding the previous rates by as much as 1.5 percent. Accordingly, we set $g^H = (g_z^H)^{1/(1-\theta\epsilon)} = 0.0292$.

Our computational exercise consists of simulating the artificial economy for the following sequence of realized shocks:

$$x_t = \begin{cases} (g_z^L, 0), & \text{for } t = -\infty : 0 \\[2ex] (g_z^L, \overline{p}), & \text{for } t = 1 : N \end{cases}$$

In words, we assume that the economy has been in the state $x_1 = (g_z^L, 0)$ for a long period of time. This period has been sufficiently long for the economy to converge to the long-term equilibrium associated with this state. Starting from this initial equilibrium, the switching probability increases to $\overline{p}$ and the new state becomes $x_2 = (g^L, \overline{p})$. We will then consider a sequence of realizations of this state and we compute the transition to the new long term equilibrium associated with x_2. Therefore, after the arrival of $\overline{p}$, the economy remains in the low growth regime for several periods even though in each period there is a positive probability of transiting to the New Economy. Although these are very extreme assumptions, they capture the main idea of the paper, that is, the fact that in the 1990s the likelihood of the New Economy increased. This shift in expectations was driven by the rapid diffusion of information and communication technologies. The assumption underlying the numerical exercise is that the economy did not switch to the new growth regime. Only the expectations about the new regime have changed. This assumption allows us to isolate the mechanism described in the paper which solely relies on expectations and not direct technological improvements.

Calibration of other parameters: The period in the model is one year. The intertemporal discount rate (equal to the interest rate) is set to $r = 0.02$ and the survival probability to $\alpha = 0.99$; we will report on the sensitivity of the results with respect to r.

The detrended disutility from working takes the form $\varphi(l) = \pi \cdot l^{\nu}$ and the supply of labor is governed by the first order condition $\nu \pi l^{\nu-1} = w\alpha/(1+r)$. The elasticity of labor with respect to the wage rate is $1/(\nu - 1)$. Blundell & MaCurdy (1999) provide an extensive survey of studies that estimate this elasticity. For men, the estimates range between 0 and 0.2, while for married women they range between 0 and 1. Based on these numbers, we use a labor elasticity of 0.5 which implies a value of $\nu = 3$. We will consider other values in the sensitivity analysis. After fixing ν, the parameter π is chosen so that one third of available time is spent working.

The fraction of agents with entrepreneurial skills e determines the ratio of workers to firms, which affects the level of the equilibrium wage rate. However, for the quantities we are interested in, this parameter is irrelevant[8]

The production function is specified as $(k^{\epsilon} l^{1-\epsilon})^{\theta}$. Atkeson, Khan, & Oha-

[8]Whatever the value of e, we can set π so that the working hours satisfy the calibration target of one third and the labor market is in equilibrium.

nian (1996) provide some discussion that justifies a value of $\theta = 0.85$. This is also the value used by Atkeson & Kehoe (2001). The parameter ϵ, then, is set so that the labor income share is close to 0.6. For unconstrained firms the labor income share is equal to $\theta(1-\epsilon)$. Because most of the production comes from unconstrained firms, we use this condition to calibrate ϵ. Using the first order condition for the optimal input of capital (which is satisfied for unconstrained firms), the depreciation rate can be expressed as $\delta = \theta\epsilon/(K/Y) - r$. With a capital-output ratio of 2.5 and the above parameterization of θ, ϵ and r, the depreciation rate is $\delta = 0.08$.[9]

We assume that the survival probability ϕ takes two values, $\underline{\phi}$ and $\overline{\phi}$, with $\underline{\phi} < \overline{\phi}$. When firms are born, their initial survival rate is $\underline{\phi}$. Over time, however, these firms may become mature with some probability χ and their survival probability becomes $\overline{\phi}$ forever. This allows us to capture the dependence of the firm survival on age. We set $\underline{\phi} = 0.91$ and $\overline{\phi} = 0.99$. Together with the one percent probability that the entrepreneur dies, these numbers imply that new firms face a 10 percent probability of exit while the exit probability of mature firms is 2 percent. These numbers are broadly consistent with the U.S. data for the manufacturing and business service sector as reported by OECD (2001). According to this source, only 50% of entrant firms are still alive after 7 years which is consistent with the 10% yearly probability of exit assumed for new firms. After parameterizing $\underline{\phi}$ and $\overline{\phi}$, the probability that a firm becomes mature is set such that the average exit rate is 6 percent. This is in the range of values resulting from several empirical studies about firms' turnover as in Evans (1987) and OECD (2001).

Two other parameters need to be calibrated: the default parameter λ and the set up investment κ. These two parameters are important in determining the initial size of new firms: with larger values of these parameters, the initial size of new firms is smaller. Our calibration target is to have an initial size of firms which is 25% the average size of incumbent firms. This is somewhat larger than the value of 15% reported by OECD (2001) for the U.S. business sector. However, in the data there are other factors that reduce the initial size of new firms like learning. The parameter λ is especially important to determine the feasible range of the size distribution of firms. In particular, for small values of λ, the initial size of new firms can not be very small. We

[9] Notice that the economy-wide capital-output ratio will not be exactly 2.5 because in the economy there are also constrained firms. However, because the production share of constrained firms is small, these numbers will not be very different from the targets.

set $\lambda = 3$ because this allows us to have an initial size of new firms which is equal to 25% the size of incumbent firms. After setting $\lambda = 3$, we determine the value of κ such that k_0 is 25% the capital of incumbent firms.[10] The full set of parameter values is reported in Table 2.

Table 2: Parameter values.

Growth regimes	$g \in \{0.0142, 0.0292\}$
Transition probability parameter	$\rho \approx 0$
Intertemporal discount rate	$r = 0.02$
Disutility from working $\varphi(h) \equiv \pi \cdot h^{\nu}$	$\nu = 3$
	$\pi = 0.002$
Survival probability of agents	$\alpha = 0.99$
Survival probability of projects	$\phi \in \{0.91, 0.99\}$
Probability the firm matures	$\chi = 0.021$
Production technology $(k^{\epsilon} l^{1-\epsilon})^{\theta}$	$\theta = 0.85$
	$\epsilon = 0.294$
Depreciation rate	$\delta = 0.08$
Set up investment	$\kappa = 0.44$
Default parameter	$\lambda = 3$

Results: Figures 7 and 8 plot the detrended responses of the economy after the arrival of a sequence of signals $\overline{p}$ and the economy remains in the low growth regime $g^L = (1 + g_z^L)^{\frac{1}{1-\theta\epsilon}} - 1 = 0.0142$. Several values of $\bar{p}$ are considered.

The plots in Figure 7 display the set of events through which the expectations about the New Economy leads to an improvement in the productivity of labor. First, the higher value of p increases the value of firms and generates a stock market boom (plot a). The asset price increase is substantial. We will comment below how the model can generate this large stock market boom. After the stock market boom, new firms get higher initial financing and hire more labor (plot b). With the exception of the first period, this implies that

[10] Larger values of λ (and smaller values of κ) would reduce the speed of convergence to the unconstrained status but would not change the main results of the paper. However, we have some constraints on how large λ could be. If λ is too large, the value of defaulting will be larger than the value of the firm and the investor would prefer to default.

the demand of labor increases and pushes up the wage rate (plot c).[11] A higher wage rate induces unconstrained firms to reduce employment (plot d). Also, the higher wage rate leads to substitute labor and increases the intensity of capital (plot e). As a result of these events, the productivity of labor increases as shown in panel f.

The productivity improvement derives in part from the reallocation of labor to younger firms (reallocation effect) and in part from the increase in capital intensity (capital deepening effect). Given that all firms run the same production technology $z(k^{\epsilon}l^{1-\epsilon})^{\theta}$ and choose the same capital-labor ratio, the aggregate productivity of labor can be written as:

$$\text{LabProd} = z\left(\frac{K}{L}\right)^{\theta\epsilon}\sum_i s_i L_i^{\theta-1} \tag{18}$$

where L_i is the labor employed by all firms of type i and s_i is their share of aggregate labor.[12] Taking logs and first difference we get:

$$\Delta\text{log(LabProd)} = \Delta\text{log}z + \theta\epsilon\Delta\text{log}\left(\frac{K}{L}\right) + \Delta\text{log}\left(\sum_i s_i L_i^{\theta-1}\right) \tag{19}$$

The first element on the right-hand-size is constant because the growth rate of z does not change in our simulation exercise. The second element is the contribution of capital deepening while the third is the contribution of labor reallocation.

The last two contributions in equation (19) are shown in plots g and h. In the model, within a 5 year period, corresponding to 1995-00, labor productivity increases by about 2%, with about half of it generated by the

[11] In the first period the demand of labor decreases because old firms that are still financially constrained reduce their investment. This investment reaction of constrained old firms derives from the features of the optimal contract. In this contract investment is state contingent. When the economy is in an expansionary path and the wage rate will eventually increase, the optimal size of firms decreases. On the other hand, when the economy is in a recession path and the wage rate decreases, the optimal size of firms tends to increase. This implies that the growth incentive for the firm is lower when the economy is expanding. Anticipating this, the optimal contract recommends higher levels of investments when the economy is in a recession path and lower levels of investment when the economy is in an expansionary path. The negative investment effect coming from existing constrained firms will be overturned later on by the entrance of new firms.

[12] The fact that the capital-labor ratio depends only on the wage rate is a consequence of the particular functional form chosen for the default value.

reallocation effect and the other half by capital deepening. This corresponds roughly to about half of the actual productivity increase for that period discussed in section 1.

Notice that if we use a constant return-to-scale production function to evaluate the contribution of the different factors to the productivity change, the last term of equation (19) would be zero because $\theta = 1$. Consequently, the reallocation effect would be mistakenly attributed to an exogenous increase in the growth rate of z or multifactor productivity.

Figure 8 shows the impact of the higher p on other macroeconomic variables. Again, with the exception of the first period, capital, employment and production all get a positive and persistent impulse from the higher switching probability. It is also interesting to observe that a small value of $\overline{p}$ can have significant effects on the economy. This is because the "signal" is highly persistent in our calibration. Even if there is only 10 percent probability of switching to the New Economy, this probability is present in every period and once the economy has switched, it will remain in the high growth regime with very high probability. The last panel of Figure 8 plots the fraction of firms that are not financially constrained. As can be seen, this fraction increases with the signal. This is another way to see how the stock market boom relaxes the tightness of financial constraints.

4.1 More on the reallocation effect

To get a better understanding of our quantitative results, we present here a simple example covering some of the factors that determine the size of the reallocation effect. Assume there are only two types of firms: small constrained firms and large unconstrained firms. A small firm employs l_1 units of labor and a large firm employs l_2 units of labor. Given the fraction of small firms, n, the average (per-firm) employment is equal to $l = n \cdot l_1 + (1-n) \cdot l_2$. The reallocation term derived above, that is, the last term in equation (19), can be rewritten as:

$$\Delta\log\left(\sum_{i=1,2} s_i L_i^{\theta-1}\right) = \Delta\log l^{\theta-1} + \Delta\log\left[n\left(\frac{l_1}{l}\right)^{\theta} + (1-n)\left(\frac{l_2}{l}\right)^{\theta}\right] \quad (20)$$

The first term on the right-hand-side is the "level effect". With larger average scale, productivity is reduced, given decreasing returns to scale. The second term on the right-hand-side is the "relative reallocation effect": the smaller the difference in size between small and large firms, the greater is the productivity of labor. As we have shown in the previous section, a stock market boom generates an increase in the average size of firms l (level effect) which has a negative impact on productivity. It also reallocates labor from large firms to small firms—that is, it increases l_1/l and decreases l_2/l—which has a positive impact on productivity.

In our calibration, we have set $\theta = 0.85$. With this value of θ, if the average labor supply increases by 6.6%, the average productivity of labor falls by 1%. In the baseline model the supply of labor increases by about 3%. Therefore, the level effect reduces productivity by about 0.5%. However, this is more than compensated by the reallocation of labor from large to small firms. Table 3 shows the increase in productivity due to the relative reallocation effect (last term in equation 20), from eliminating all financial frictions. We consider several initial values of n and l_1/l_2 and the elimination of all the financial frictions implies $l_1/l = l_2/l = 1$. This is the maximal effect that can be obtained through the relative reallocation mechanism.

Table 3: Relative reallocation effect from eliminating all the financial constraints. The value of θ is 0.85.

	$n = 0.3$	$n = 0.4$	$n = 0.5$	$n = 0.6$
$\frac{l_1}{l_2} = 0.1$	3.04	4.15	5.29	6.41
$\frac{l_1}{l_2} = 0.2$	1.98	2.62	3.21	3.70
$\frac{l_1}{l_2} = 0.3$	1.31	1.68	2.00	2.21

As can be seen from the table, for the particular range of initial conditions, the potential gains in productivity due to the relative reallocation mechanism are much larger than the losses in productivity induced by the level effect.

4.2 Sensitivity analysis

In this section, we document the sensitivity of our quantitative results to changes in the interest rates, r, the labor supply elasticity, $1/(\nu-1)$, and the degree of decreasing returns to scale, θ.

As we have seen in the previous section, the model can generate large stock market booms after small changes in the switching probability p. The calibration of the interest rate r and the survival probability ϕ are key for generating these large asset effects. To see this, consider the steady state value of a firm once it reaches the unconstrained status:

$$\frac{d}{1-\left(\frac{\alpha\phi}{1+r}\right)(1+g)}. \tag{21}$$

Here d denotes the detrended values of dividends which is constant in the steady state. The term $\alpha\phi/(1+r)$ is the discount factor. This factor is multiplied by $1+g$ because dividends are detrended. As can be seen in equation (21), the value of the firm gets more responsive to changes in g as the term $\left(\frac{\alpha\phi}{1+r}\right)(1+g)$ approaches 1. Because this term depends negatively on the interest rate, smaller is r and larger is the price sensitivity to g.

The requirement for a sizable stock market increase partly motivates our choice of specification for the survival probability ϕ as taking two values $\underline{\phi}$ and $\bar{\phi}$. Having a low survival probability for young firms allows us to generate the empirically observed high turnover rates even if mature firms have a low exit rate. The high survival rate of mature firms is important to generate large stock price movements because a large fraction of the market capitalization comes from these firms.

Figure 9 plots the stock market value and other variables for different values of the interest rates. If we reduce the interest rate to 1.5% from our benchmark value of 2%, then we can generate a stock market boom that is close to 100 percent. When the interest rate is 3%, instead, the stock market boom is much smaller. Notice that even if the impact on the stock market is very sensitive to the interest rate, the impact of the market boom on productivity does not change much. This is because the stock market boom obtained in the baseline model already eliminates almost all the financial restrictions faced by new firms. The economy then, is close to a frictionless economy and further increases in the stock market have a modest impact on the real sector of the economy.

Figure 10 and 11 show sensitivity to changes in the labor supply elasticity and the curvature of the production function. For the labor supply elasticity, Figure 10 plots the impulse responses of the stock market and productivity for different values of the parameter ν. In these impulse responses the value of the switching probability is $\bar{p} = 0.2$. When labor is not very elastic, a positive signal has a larger effect on productivity but a smaller effect on aggregate employment and production. Figure 11 presents the sensitivity analysis with respect to the returns to scale parameter θ. In changing θ we also change λ and κ so that the initial size of new firms is the same as in the previous calibration before the increase in p. When θ is small, and thus the production function more concave, the expectation of higher future growth generates larger productivity gains and larger impacts on the aggregate economy. These results confirm our discussion in Section 2.

5 Additional empirical evidence

In this final section we provide some more direct empirical evidence in support of the reallocation mechanism underlying the productivity gains emphasized in the previous sections. The main feature of this mechanism is that labor has been reallocated to firms that are financially constrained. To verify this mechanism we would need cross-sectional panels of firms which unfortunately are not available for the years under consideration. However, we have some data on the size distribution of employers (firms). As long as there is some correlation between the size of employers and the tightness of financial constraints, we can use the size of firms as a proxy for the tightness of financial constraints.

The County Business Patterns published by the Census Bureau contains annual data on the number of workers employed by firms of a certain size. Most of the country's economic activity is covered, with the exception of self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees. Firms are grouped into 3 size classes: firms with less than 20 employees, firms with less than 100 employees, and firms with less than 500 employees. Figure 12 reports the percentage of firms and the employment share in each of these three size classes over the period 1988-99. As can be seen, the number of firms and the employment share of smaller firms (the left section of the distribution) have declined during the 1990s. Furthermore, this tendency seems to accelerate in the second half of the 1990s.

Figure 12 points out that the left tail of the distribution of firms and employment in smaller firms has shrunk, which is consistent with our reallocation mechanism. Concerning the right tail of the distribution with the large firms, we do not have data for each year during the 1990s and or the whole economy. However, we have some concentration indices for the manufacturing sector for the years 1992 and 1997. These indices are constructed using data from the 1992 and the 1997 Economic Census (which is conducted with a 5 years frequency). Table 4 reports these indices for five classes of manufacturing firms: the 50 largest; the 51st to 100th largest; the 101st to 150th largest; the 151st to 200th largest; the firms smaller than the 200th largest. The ranking is based on value added.

Table 4: Share of Industry Statistics for Companies Ranked by Value Added.

	Total	Production workers			Value	New capital
	employees	Total	Hours	Wages	added	expenditures
			1992 Economic Census			
50 largest	13.0	12.8	12.9	19.3	23.7	21.8
51st to 100th largest	4.5	4.3	4.4	5.4	8.4	10.8
101st to 150th largest	3.9	4.3	4.4	4.9	5.5	6.8
151st to 200th largest	2.8	3.0	3.0	3.5	4.0	5.7
201st largest and smaller	75.8	75.5	75.3	66.8	58.3	55.0
			1997 Economic Census			
50 largest	11.7	10.6	11.1	16.8	24.0	21.3
51st to 100th largest	4.4	4.2	4.4	5.2	7.7	7.3
101st to 150th largest	3.6	3.7	3.7	4.4	5.2	5.3
151st to 200th largest	2.8	2.9	3.0	3.3	3.8	4.1
201st largest and smaller	77.5	78.6	77.7	70.4	59.3	62.0

Source: *Concentration Ratios in Manufacturing: 1992 and 1997 Economic Census*

Table 3 shows that the employment share of the 1997 largest firms has decreased relative to 1992. This tendency can also be observed in terms of shares of new capital expenditures. Therefore, according to this table the right tail of the distribution seems to have shrunk in relative terms. This pattern is consistent with our reallocation mechanism. There is also another pattern shown by the table which is worth emphasizing. Although the share of employment of the 50 largest firms has decreased, the share of value added has not decreased. At the same time, when we look at the class of smaller firms, the increase in the share of value added is smaller than the increase in share of employment. This seems to suggest that the labor productivity of the largest firms has increased relative to the productivity of smaller firms, which is consistent with our reallocation mechanism. To summarize, while the evidence provided in this section is not a rigorous proof of our reallocation mechanism, it is fully consistent with our story.

6 Conclusion

This paper develops a general equilibrium model with financial market frictions in which stock market booms can generate an economic expansion with gains in productivity. The reaction of the economy to a stock market boom is consistent with the 1990s expansion of the US economy characterized by higher investment, higher productivity, higher employment and higher production. This interpretation of the U.S. expansion may coexist with the more traditional view which assigns a direct role to technological improvements related to information and communication technologies as in Cooley & Yorukoglu (2001). However, the recent survey of Baily (2002) points out that, although information and communication technologies were important for the productivity revival of the 1990s, other factors must have also played an important role. This paper provides a complementary explanation for these productivity gains which is consistent with the view of more recent studies emphasizing the "business reorganization" induced by greater competition. (See McKinsey Global Institute (2001) and Lewis, Palmade, Regout, & Webb (2002)). Our view is that the driving force of this greater competition was the asset price boom experienced by the U.S. economy in the second half of the 1990s. The asset price boom allowed the financing of more investment for constrained firms and generated a reallocation of labor from less productive (unconstrained) firms to more productive ones.

Appendix: computation of equilibrium

Equations (12)-(16) with the initial condition $q + \kappa = S(\mathbf{s}, q)$ provide the basic conditions that need to be satisfied by the optimal contract. If we knew the terms $E(1 + g')q(\mathbf{s}')$ and $E(1 + g')S(\mathbf{s}', q')$, these conditions would be sufficient to solve the model. The numerical procedure, then, is based on the parameterization of these two functions on a grid of values for μ. The chosen parameterization depends on the particular problem we try to solve.

In the computation of the transitional equilibrium, we assume that $\rho = 0$. Therefore, when there is the arrival of the new signal $\overline{p}$, the economy continues to receive this signal with probability 1 as long as the economy does not switch to the high growth regime. Moreover, if the economy switches to the high growth regime, the switch will be permanent. The equilibrium computed under these assumptions is an approximation of the case in which ρ is not very different from zero as assumed in the calibration section. A more detailed description of the numerical procedure is available upon request from the authors.

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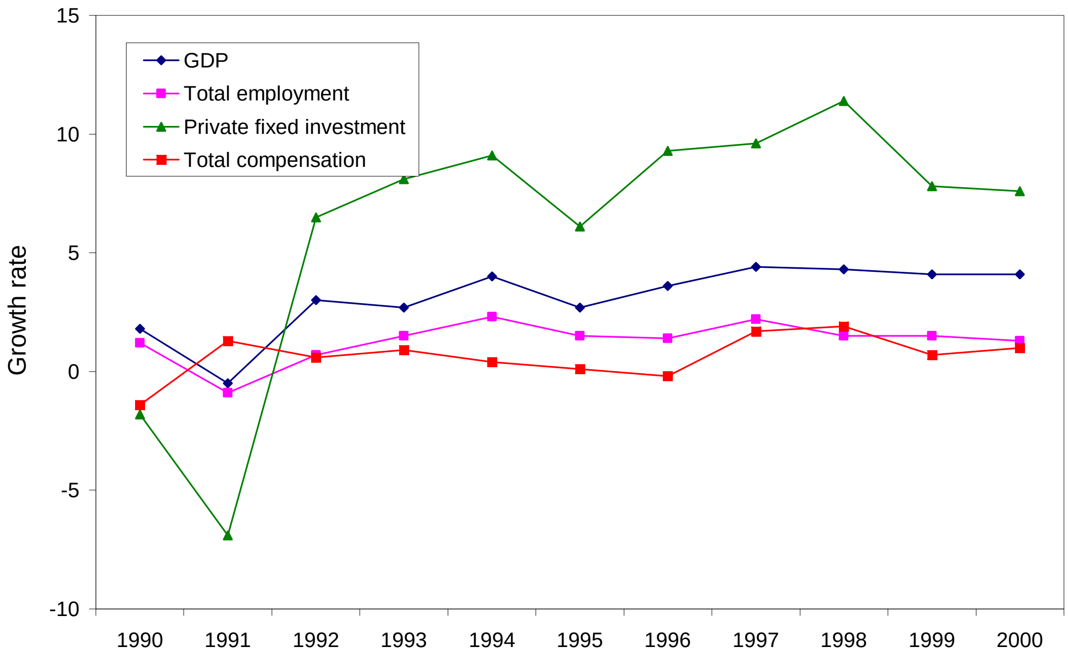
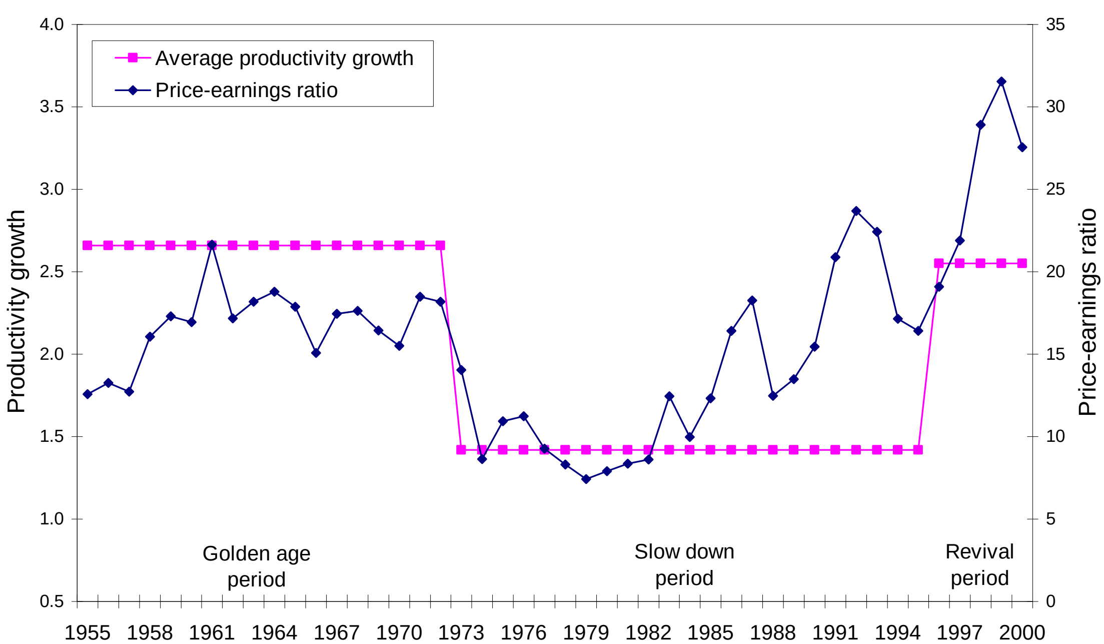
Figure 1 - Growth of macroeconomic variables



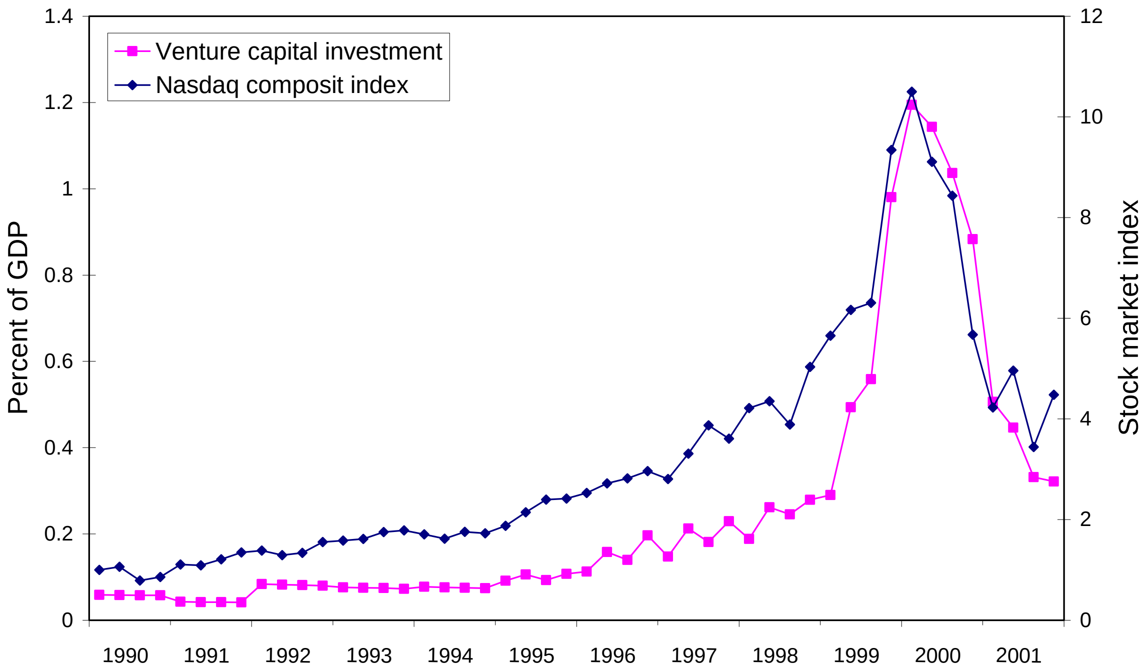
Source: Economic Report of the President (2002)

Figure 2 - Productivity growth and price-earning ratio



Source: Economic Report of the President (2002)

Figure 3 - Stock market and Venture Capital



Source: CRSP database and PricewaterhouseCoopers

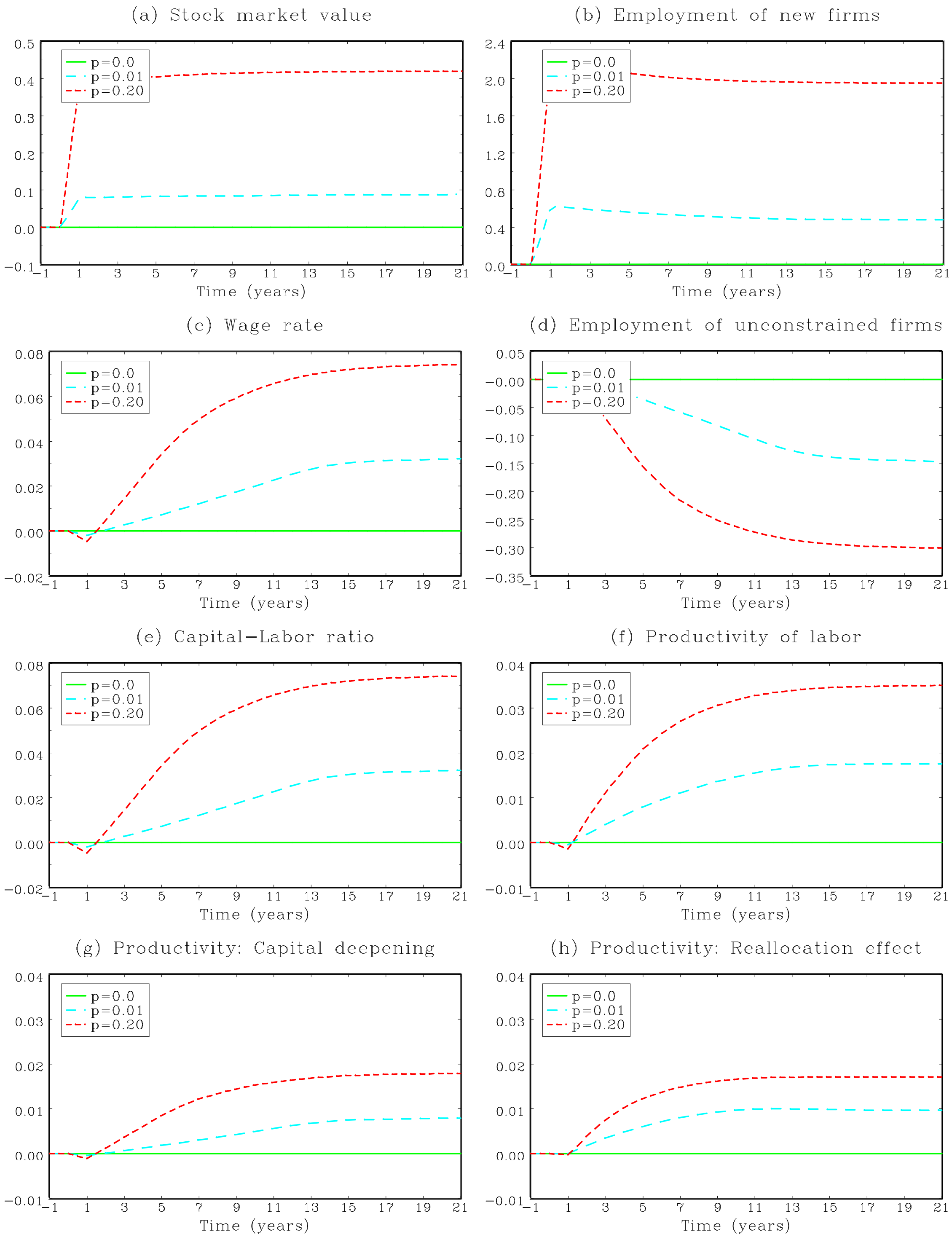


Figure 7: Impulse responses after the increase in the switching probability p.

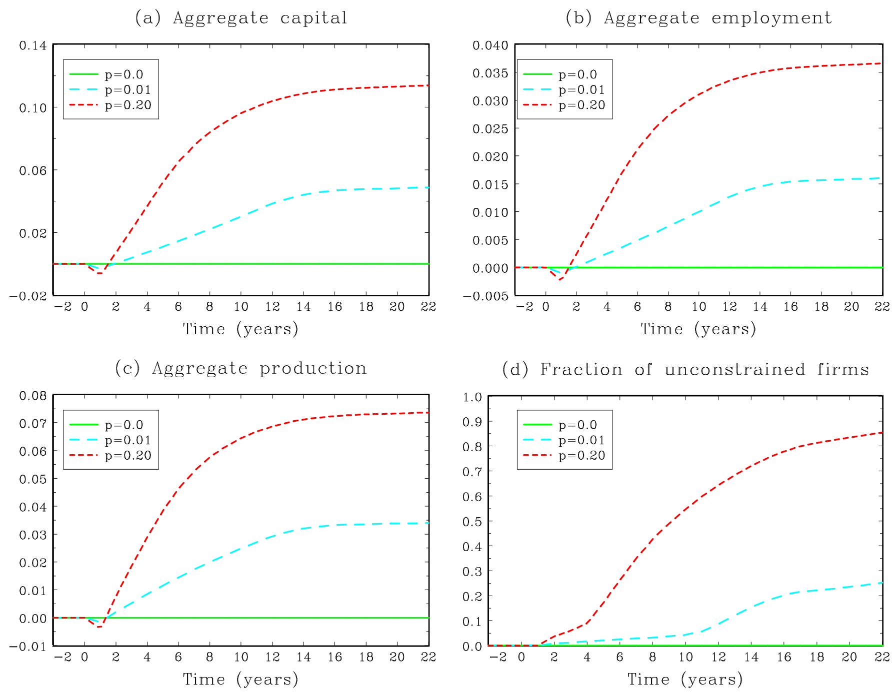


Figure 8: Impulse responses after the increase in the switching probability p.

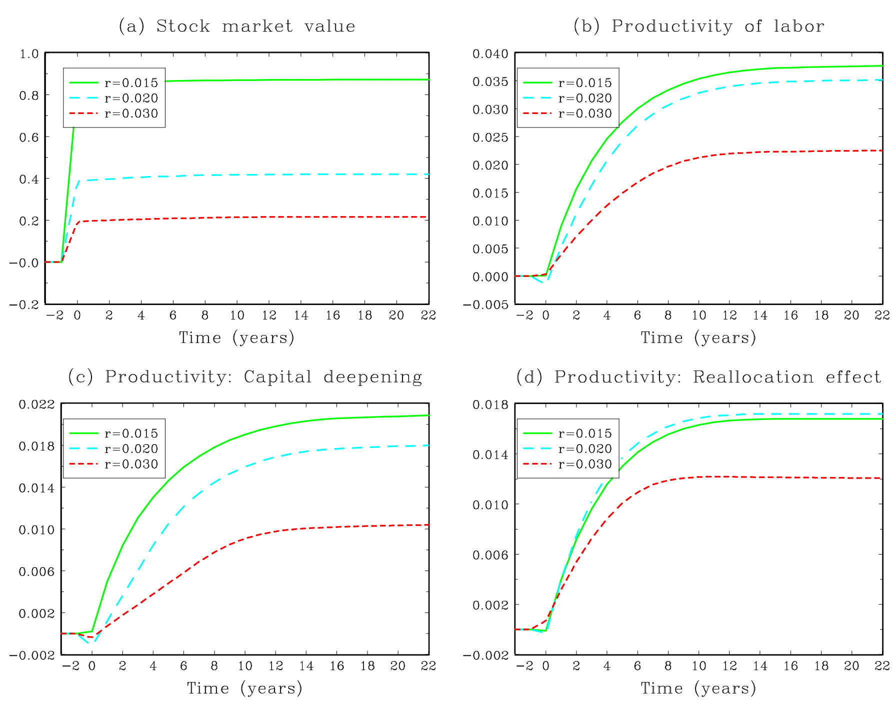


Figure 9: Sensitivity analysis for different interest rates.

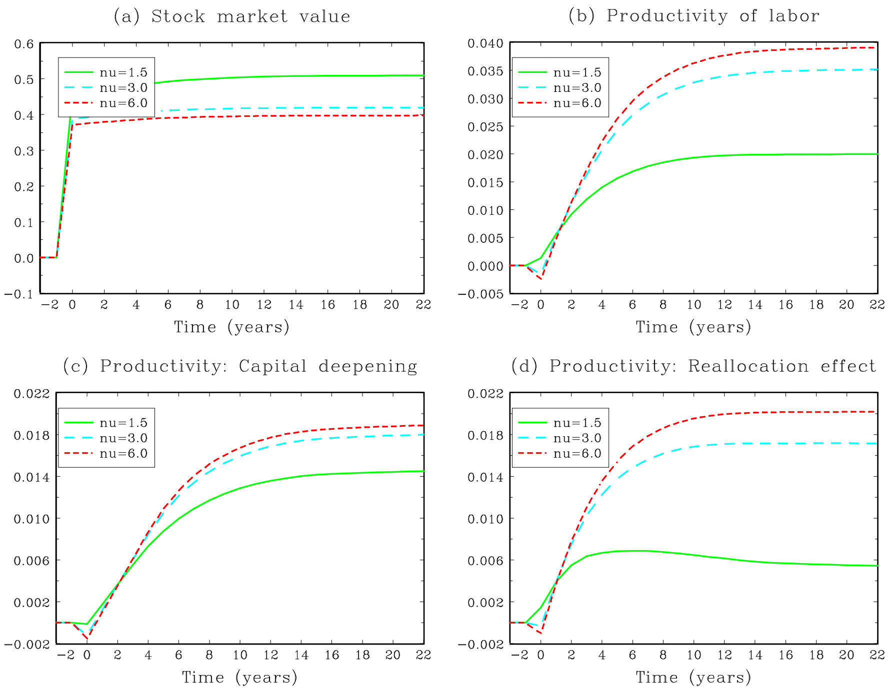


Figure 10: Sensitivity analysis for the elasticity of labor.

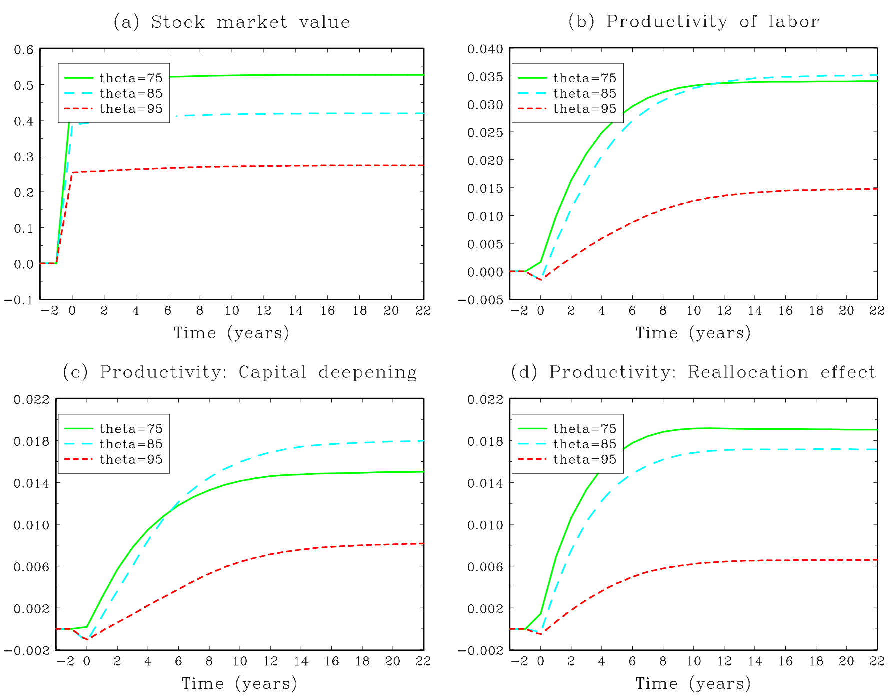


Figure 11: Sensitivity analysis for the curvature of the production function.

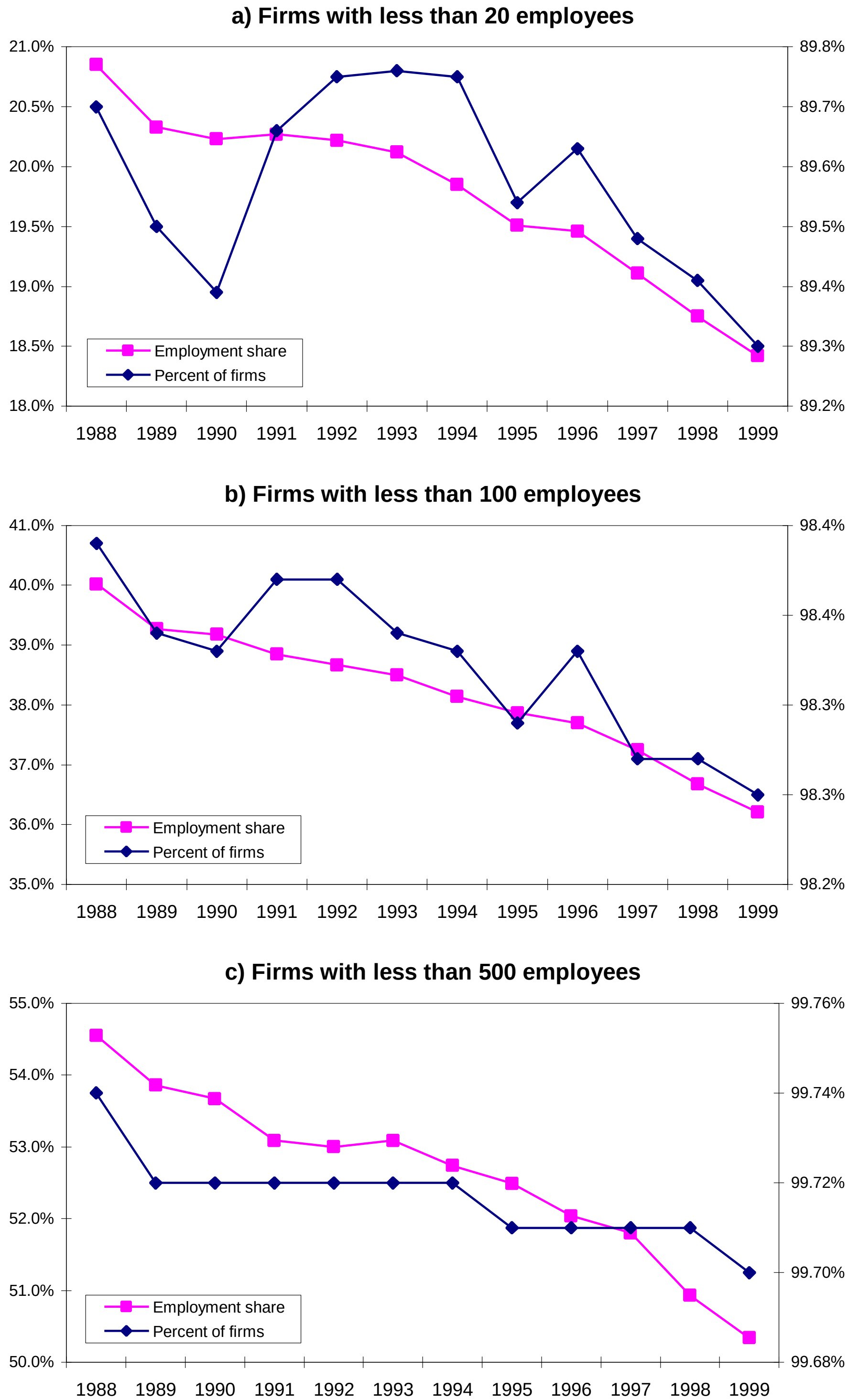


Figure 12: Dynamics in the distribution of employment among different size classes of firms.