Job Creation and Investment in Imperfect Capital and Labor Markets*

Sílvio Rendon†

University of Western Ontario

March 2004

Abstract.- This paper shows that liquidity constraints restrict job creation even with flexible labor markets. In a dynamic model of firm investment and demand for labor with imperfect capital markets, represented as a constraint on dividends, and imperfect labor markets, contained in legal firing and hiring costs applicable to some workers, firms use flexible labor contracts to alleviate financial constraints. The optimal policy rules of the theoretical model are integrated into a maximum likelihood procedure to recover the model's behavioral parameters. Data for the estimation come from the CBBE (Balance Sheet data from the Bank of Spain). I evaluate the effects of removing one imperfection at a time, and show that the relaxation of financial constraints produces
(i) more job creation than the elimination of labor market rigidities, and
(ii) a substantial increase in firm investment, which does not happen if only labor market rigidities are removed.

JEL Classification: J23, J32, E22, G31.
Keywords: Job Creation, Employment, Investment, Adjustment Costs, Liquidity Constraints, Structural Estimation.

*Updates of this paper can be downloaded at `http://publish.uwo.ca/~srendon`.

†E-mail address: srendon@uwo.ca. I started this project when I was a Research Fellow at the Bank of Spain. I am thankful to the bank's research team for several fruitful discussions and for providing the dataset. I also thank participants of seminars at U. of Maryland, NYU, Colegio de México, U. of Western Ontario, Queen's U, ITAM, IZA, LACEA, U. of Tartu, U. Pompeu Fabra, and FEDEA for their comments and valuable suggestions. Financial support of the Spanish Ministry of Science and Technology (Grant SEC 2001-0674) is gratefully acknowledged. Valeria Arza provided excellent research assistance at an early stage of this project. The usual disclaimer applies.

1 Introduction

The removal of labor market rigidities has been the cornerstone of labor policies in several Western European economies in the eighties. Policy measures for labor market liberalization included reducing firing costs, lowering government intervention in wage determination and reducing unemployment transfers. In particular, most of the observed reforms did not attempt to reduce the costs of firing the already employed, protected by strong unions, but to create a new type of contract that once expired allows firms to costlessly lay off newly hired workers. The result of these reforms was the emergence of dual labor markets consisting of permanent workers that are difficult to hire and especially difficult to fire, and temporary workers, on probation for a fixed number of months, after which they are either promoted to be permanent or dismissed. Obviously, these reforms created a strong incentive for firms to hire more temporary workers; however, the fact that firms in these economies not only operate in imperfect labor markets, but also in imperfect capital markets further limited the creation of permanent jobs to the extent of firms' financial resources.

This paper shows that financial constraints restrict job creation even when labor markets are relatively flexible. While removing labor market rigidities helps firms to create jobs and to increase capital accumulation by releasing internal resources for investment, binding liquidity constraints hinder job creation. Using a dynamic model of labor demand under liquidity constraints, I evaluate the dynamics of capital, debt and labor under three counterfactual scenarios: (i) no temporary workers, (ii) elimination of hiring and firing costs, and (iii) relaxation of financial constraints.

The first policy experiment reveals that the observed labor market reforms alleviated firms' liquidity constraints and that temporary labor did not substitute permanent labor, but labor altogether substituted capital. The second experiment shows that removing labor market rigidities would imply an initial substantial reduction in permanent labor with an increase in subsequent periods, but it would produce a modest increase in capital and a slow decrease in debt. By contrast, relaxing financial constraints would generate an important increase in capital accumulation, a sharp decrease in firms' debt and an initial decline in permanent employment followed by an important increase. Noticeably, the level of permanent labor produced by a relaxation of financial constraints would be considerably higher than the one produced by the sole elimination of labor market rigidities.

The 1990s have been a period of intensive theoretical and empirical research on the effect both of labor market rigidities and credit market frictions. The first literature is centered in explaining the effects of firing and hiring costs in labor demand, particularly in Western Europe (see, for example, Bentolila & Bertola (1990), Bentolila & Saint-Paul (1992), Hopenhayn & Rogerson (1993), Cabrales & Hopenhayn (1997) & Aguirregabiria & Alonso-Borrego (1999)). The effects of '*eurosclerosis*,' that is, labor markets with high firing and hiring costs, are ambiguous. In good times, sclerotic labor markets create fewer jobs than free labor markets; however, in bad times, sclerotic labor markets defend existing jobs better. The second literature focuses on the effects of credit market frictions on the real economy (see Bernanke, Gertler and Gilchrist (1999) for a survey). Under liquidity constraints the Modigliani and Miller (1958) proposition does not hold and firms' investment is limited by their internal collaterizable resources. In this environment, real and nominal shocks to the economy are magnified and last longer.

These literatures do not usually refer to each other: typically, the analysis of *eurosclerosis* abstracts from capital markets, whereas the analysis of capital market imperfections does not usually consider the labor market in a meaningful way. The present paper proposes a framework to analyze these two issues jointly.[1] It is a dynamic model where firms decide on a level of investment, permanent and temporary labor and debt subject to financial constraints, bankruptcy conditions and firing and hiring costs. The behavioral parameters of the theoretical model are estimated using its policy rules as an input in a maximum likelihood procedure. These parameters are used to perform the aforementioned policy experiments. The data come from the CBBE (Balance Sheet data from the Bank of Spain) and include financial variables as well as information on permanent and temporary employment.

Among Western European countries, Spain has been the country with the largest unemployment rate, almost 20% for more than a decade. In 1984 a labor reform attempted to counteract the sharp increase in unemployment suffered during the 'transition phase' to a free economy. This reform basically created temporary labor in Spain, so that after 1984 there was an important expansion of this type of contract. At the same time, it is well-documented that Spanish firms face significant financial constraints, so that financial variables have an important on firms' investment.(Alonso-Borrego and Bentolila 1994, Estrada and Vallés 1995) Therefore,

[1] There is a relatively recent and growing literature that focuses on the link between employment and credit market imperfections (Sharpe 1994, Nickel and Nicolitsas 1999, Acemoglu 2001, Wasmer and Weil 2002, Barlevy 2003). This literature, however, does not usually distinguish between temporary and permanent labor, which is crucial for the European case.

the Spanish economy illustrates well the kind of the imperfections faced by several European economies.

The remainder of the paper is organized as follows. The next section details the Spanish regulation wage setting and for hiring and firing workers. Section 3 explains the model and characterizes the optimal solution. Section 4 describes the data and documents their basic trends. Section 5 discusses the maximum likelihood estimation procedure. Section 6 presents the results of the estimation, the behavioral parameters and an assessment of how well the model fits the data. Section 7 performs the three policy experiments mentioned above. The main conclusions of this paper are summarized in Section 8.

2 Institutional Background

In the 50s and the 70s several Western European governments used dismissal costs as a tool to discourage job destruction. However, in the 80s and 90s, confronted to persistently high unemployment rates, these governments reduced dismissal costs to some extent and created fixed-term contracts, producing thereby the uprising of dual labor markets. Spain is the country where temporary contracts are particularly important, and as such provides a good illustration on how these dual labor markets work.

In Spain, for declaring a so-called 'fair' dismissal a firm has to give a 3 month notice before firing a worker under a permanent contract and give a reason, which can be

- disciplinary or if the worker is found incompetent, in which case the worker can appeal and during the process he or she continues earning a salary;
- economic or technical, in which case in practice the firm has to justify that it had continuous losses for two years.

In this case, the worker receives 20 days of monthly wage per year worked, up to 12 monthly wages. If the worker goes to court and wins, the dismissal is declared 'unfair,' in which case the worker receives 45 days of monthly wage per year worked, up to 42 monthly wages. Only 15% of job terminations are settled in court, of which 73% are favorable to the workers.

Before 1984 fixed-term or temporary contracts in Spain were only 'causal,' that is, only applicable to seasonal jobs or to jobs replacing workers that were in maternity leave. In 1984 a reform broadened the scope of temporary contracts, so they became mostly 'noncausal.' In Spain, a temporary contract lasts at least six months and at most three years. After three years of being temporary, a worker has to be either promoted to sign a permanent contract or be fired. If the firm wants to terminate the contract before the contract length, the normal procedure applies, that is, there are high firing costs. Otherwise there is only a severance payment of 12 monthly wages per year worked. Courts are not involved in job termination under a temporary contract.

In Spain, unions play a crucial role in wage determination, as representation of trade unions is independent of membership. This means that union agreements affect almost the whole labor force. Moreover, by law only the most representative unions, two confederations, which receive public financing, are allowed to negotiate wages. There are practically no minority trade unions. The effect of this high degree of centralization and coordination is that wages negotiated by unions, are well above the minimum wage: the ratio average wages/minimum wages is 31.2%. In Portugal, with less centralization, the corresponding ratio is 42.6% (Bover, García-Perea and Portugal 2000). Thus, wages do not adjust to specific firms' circumstances; the negotiation of wage increases, closely related to the CPI, is centralized.

These two aspects of Spanish labor markets, high firing costs and wage rigidity, play a crucial role in the model described in the next section.

3 Model

I use a dynamic model where firms maximize the expected discounted value of their stream of dividends by choosing investment, debt, and two types of labor. It is a neoclassical model of investment on the lines of Jorgenson (1963), extended to include liquidity constraints and bankruptcy as in Pratap and Rendon (2003), as well as hiring and firing decisions.

3.1 Environment

The following features characterize the environment in which firms operate:

- Firms are wage-takers and wages are given, which is motivated by a fully elastic labor supply or regulated wages.

- There are two types of workers, with given productivities. Flexible or temporary workers are unskilled and rigid or permanent workers are skilled. The analysis abstracts from the promotion structure.[2]

- Credit market imperfections are assumed to be exogenous and characterized by a dividend constraint, motivated by firms having an exogenous limit for issuing fresh equity.

3.2 The Firm's Problem

The firm operates in a stochastic environment where it chooses a sequence of investment I, rigid labor H, flexible labor L, and debt B to maximize the discounted stream or dividends D:

$$\sum_{t=0}^{\infty} \frac{E_t D_t}{(1+\rho)^t},$$

being ρ the discount rate, common for all firms.[3] Dividends are defined as

$$D = \theta K^{\alpha} \left(H^{\gamma} + \lambda L^{\gamma}\right)^{\frac{\beta}{\gamma}} - I - w_H H - c(H_{-1}, H) - w_L L - (1+r)B + B',$$

that is, revenues from production which depend on capital K and on two types of labor, rigid labor H and flexible labor L, net of investment, both labor costs, adjustment costs of rigid labor and net debt variation. The firm's risky environment is captured by a total factor productivity θ that follows a Markov process $P(\theta'|\theta)$ parameterized as an AR(1) process: $\theta' \sim N\left(\mu + \phi\theta, \sigma^2\right)$. The firm and the lenders observe this productivity before making investment, employment, and borrowing decisions. Technology is contained in a Cobb-Douglas production function in capital and efficiency units of labor, with parameters α and β, respectively. Rigid and flexible labor are transformed into efficiency units of labor with a CES technology with parameters γ and λ.

[2] The few analyses of the promotion structure from temporary to permanent employment in the literature made so far are based on the theory of efficiency wages (Güell 2000) or on human capital theory (Nagypál 2002). However, most of the research done so far simplifies the analysis by assuming two types of workers.

[3] In what follows, except in summations or in the likelihood funcion, variables in the current period will not carry a subscript, variables in the next period will be denoted by 'prime,' and variables in the past period will have the subscript -1.

Capital is accumulated following the law of motion:

$$K' = (1 - \delta_k)K + I,$$

where δ_k is the depreciation rate of capital. The wage rate of rigid labor is w_H, and the wage rate of flexible labor is w_L. The firm can adjust flexible labor at no cost, but it has to incur in hiring and firing costs to adjust rigid labor. In this context, it is sensible to assume a linear adjustment cost function for labor:

$$c(H_{-1}, H) = C \max\left[(H - (1 - \delta_h) H_{-1}), 0\right] - F \min\left[(H - (1 - \delta_h) H_{-1}), 0\right]$$

where C is the hiring cost and F is the firing cost, both in terms of unit variation in rigid labor. Workers quit their jobs at an exogenous rate δ_h without producing any cost for firms. The labor adjustment cost function captures the labor market imperfection; the capital market imperfection is that the firm has an exogenous limit for issuing fresh equity, that is, there is a lower bound on dividends:

$$D \geq \overline{D}. \tag{1}$$

In the current period the firm pays debt B at interest rate r, determined both in the past period, and contracts next period's debt B' at interest rate r'. The firm does not lend money in any way, that is, it is constrained to have a nonnegative level of debt:

$$B' \geq 0. \tag{2}$$

The firm exits the market or goes bankrupt, if its value falls below zero. In that case, the firm cannot meet its current obligations out of their current assets and shuts down forever. Competitive lenders, who are aware of that possibility, establish a debt contract so that they earn zero expected profits. Assuming that lenders face an elastic supply of funds at the risk free rate ρ, the interest rate r' charged on debt B' is determined by the zero profit condition:

$$G(r') = \pi(1 + r')B' - (1 + \rho) B' = 0,$$

where π is the probability of survival. The first term is the expected return of the lender while the second term is the opportunity cost of the funds. This equation pins down the interest rate and is explained below in greater detail.

The timing of events are the following: (i) the firm enters the period with a level of capital K and a level of debt B contracted in the past period at the interest rate r; and because there are adjustment costs to rigid labor, the firm needs to keep track of the level of rigid labor in the previous period H_{-1}; (ii) productivity θ is realized; the firm stays in business in its value is nonnegative and exits otherwise; (iii) the surviving firm chooses investment, new debt and the two types of labor.

Consequently, the value of the firm is determined by the following Bellman equation:

$$\begin{aligned} V\left(K, H_{-1}, (1+r)\,B, \theta\right) &= \max_{K',H,L,B'} \Big\{ \theta K^{\alpha}\left(H^{\gamma}+\lambda L^{\gamma}\right)^{\frac{\beta}{\gamma}} + (1-\delta_k)K - K' \\ &\quad -w_H H - c(H_{-1},H) - w_L L - (1+r)B + B' \\ &\quad + \frac{1}{1+\rho} E \max\left[V(K', H, (1+r')\,B', \theta'), 0\right] \Big\} \\ &\quad \text{subject to (1), and (2).} \end{aligned}$$

In this environment the value of the firm is increasing in capital and productivity, decreasing in total debt payments and it is ambiguous in lagged rigid labor, i. e., $V_K > 0, V_{H_{-1}} \lesseqgtr 0, V_{(1+r)B} < 0, V_{\theta} > 0$. Before deciding on the choice variables, the firm determines an exit rule. Let the lowest productivity that leaves the firm in business be

$$\underline{\theta} = \left\{\theta \left| V\left(K, H_{-1}, (1+r)\,B, \theta\right) = 0 \right.\right\};$$

then, the exit rule implies that

$$\begin{aligned} \text{if } \theta &\geq \underline{\theta}, \qquad \text{the firm stays;} \\ \text{if } \theta &< \underline{\theta} \qquad \text{the firm exits.} \end{aligned}$$

Hence, the probability of survival next period is $\pi = \Pr(\theta' > \underline{\theta}' | \theta) = 1 - \Phi\left(\kappa'\right)$, where $\kappa' = \frac{\underline{\theta}' - \gamma\theta - \mu}{\sigma}$ and $\Phi\left(.\right)$ is the normal cumulative distribution function. By the implicit function theorem applied to the definition of $\underline{\theta}$, we obtain the following derivatives:

$$\begin{aligned} \underline{\theta}_{K'} &= -\frac{V_{K'}}{V'_{\theta}} < 0; & \underline{\theta}'_{B'} &= -\frac{V_{(1+r')B'}}{V'_{\theta}}\left(1+r'\right) > 0; \\ \underline{\theta}_{r'} &= -\frac{V_{(1+r')B'}}{V'_{\theta}} B' > 0; & \underline{\theta}'_{H} &= -\frac{V_H}{V'_{\theta}} \lesseqgtr 0; \end{aligned}$$

which imply that the survival probability increases in capital, decreases in debt and in the interest rate, and has an ambiguous sign for lagged rigid labor. The exit rule is a Chapter 7 bankruptcy, that is, a firm declares bankruptcy when it cannot meet its debt obligations but is allowed to keep 'the tools of its trade.'

Having determined the effect of the state variables on the firm's survival probability, I define the firm-specific interest rate from the zero-profit condition:

$$r^{'}\left(K^{'},H,B^{'},\theta\right)=\left\{r^{'}\middle|\,G\left(r'\right)=0\right\}. \tag{3}$$

This equation gives us the supply for debt faced by the firm. Using the implicit function theorem in this equation, one can determine that the interest rate is decreasing in capital, increasing in debt, and ambiguous in rigid labor; more precisely, $r'_{K'}=\underline{\theta}'_{K'}\Upsilon<0$, $r'_{H}=\underline{\theta}'_{H}\Upsilon \lesseqgtr 0$, and $r'_{B'}=\underline{\theta}'_{B'}\Upsilon>0$, where $\Upsilon=\frac{\lambda(\kappa')(1+r')}{1-\lambda(\kappa')(1+r')\underline{\theta}'_{r'}}>0$, and $\lambda\left(\kappa'\right)=\frac{\frac{1}{\sigma}\phi(\kappa')}{1-\Phi(\kappa')}>0$ is the inverse Mills's ratio, which is positive as truncation occurs from below. The interest rate ranges between ρ, if its survival were guaranteed, and infinity, if it goes bankrupt next period with certainty. The interested reader will find more details in Appendix A1.

3.3 Optimal Policy

To solve this problem, I form the Lagrange equation, which becomes the new maximand:

$$\begin{aligned}Z\left(K',H,L,B'\right) \;=\;& (1+y_D)\left[\theta K^{\alpha}\left(H^{\gamma}+\lambda L^{\gamma}\right)^{\frac{\beta}{\gamma}}+(1-\delta)K-K'\right.\\ &\left.-w_H H-c(H_{-1},H)-w_L L-(1+r)B+B'\right]-y_D\overline{D}\\ &+\frac{1}{1+\rho}\int\max\left[V(K',H,\left(1+r'\right)B',\theta'),0\right]dP\left(\theta'|\theta\right)+y_B B'.\end{aligned}$$

The first order conditions for this problem are then

$$\begin{aligned} Z_{K'} &= -(1+y_D) + \frac{1}{1+\rho}\widetilde{E}V_{K'} = 0; \\ Z_H &= D_H(1+y_D) + \frac{1}{1+\rho}\widetilde{E}V_H = 0; \\ Z_{B'} &= 1 + y_D + \frac{1}{1+\rho}\widetilde{E}V_{B'} + y_B = 0; \\ Z_L &= (1+y_D)\left[\beta\lambda\theta K^{\alpha}\left(H^{\gamma}+\lambda L^{\gamma}\right)^{\frac{\beta}{\gamma}-1} L^{\gamma-1} - w_L\right] = 0; \\ Z_{y_D} &= x - K' + B' - \overline{D} = 0; \\ Z_{y_B} &= B' = 0; \end{aligned}$$

$$\begin{aligned} \text{where } \widetilde{E}V_i &= \int_{\theta' \geq \underline{\theta}} (1+y'_D)\, D'_i dP(\theta'|\theta),\; i = \{K', H, B'\}; \\ D'_{K'} &= \alpha\theta' K'^{\alpha-1}\left(H'^{\gamma}+\lambda L'^{\gamma}\right)^{\frac{\beta}{\gamma}} + (1-\delta) - r'_{K'}B'; \\ D_H &= \beta\theta K^{\alpha}\left(H^{\gamma}+\lambda L^{\gamma}\right)^{\frac{\beta}{\gamma}-1} H^{\gamma-1} - w_H - c_2; \\ D'_H &= -r_H B' - c'_1; \\ D'_{B'} &= -(1+r') - r'_{B'}B'; \end{aligned}$$

and x are the firm's internal resources determined by the state variables and the choice of rigid and flexible labor:

$$x = \theta K^{\alpha}\left(H^{\gamma}+\lambda L^{\gamma}\right)^{\frac{\beta}{\gamma}} + (1-\delta)K - w_H H - c(H_{-1}, H) - w_L L - (1+r)B. \quad (4)$$

We have six equations to determine six variables, four choice variables and two Lagrange multipliers, which we can reduce to three. Notice that the first order condition for flexible labor Z_L is static, that is, it depends on current capital and productivity, both state variables, and on the choice of current rigid labor. Hence, the interior solution for flexible labor is defined by

$$L^i(K,H,\theta) = \left\{ L \,\middle|\, \beta\lambda\theta K^{\alpha}\left(H^{\gamma}+\lambda L^{\gamma}\right)^{\frac{\beta}{\gamma}-1} L^{\gamma-1} - w_L = 0 \right\}. \quad (5)$$

For $H = 0$ there is an explicit solution: $L^i(K,0,\theta) = \left(\frac{\beta\theta\lambda^{\frac{\beta}{\gamma}}K^{\alpha}}{w_L}\right)^{\frac{1}{1-\beta}} \equiv L_0$. Notice that $L^i_\theta > 0$ and $L^i_K > 0$ always;

$$\begin{aligned} \text{if } \gamma &< \beta, \text{ then } L^i_H > 0 \text{ and } L^i > L_0, \\ \text{if } \gamma &> \beta, \text{ then } L^i_H < 0 \text{ and } L^i < L_0, \\ \text{if } \gamma &= \beta, \text{ then } L^i_H = 0 \text{ and } L^i = L_0. \end{aligned}$$

Obviously, if $\gamma = \beta$, there is an explicit solution: $L^i(K,H,\theta) = L_0$. Also if $\gamma = 1$, there is an explicit solution: $L^i(K,H,\theta) = L_0 - \frac{H}{\lambda}$. A negative interior solution, is ruled out:

$$L(K,H,\theta) = \max\left(L^i(K,H,\theta), 0\right). \tag{6}$$

Figure 1a illustrates the solution for L as a function of H, conditional on a productivity θ and a level of capital K.

Notice also that the first order condition $Z_H = 0$ holds only if the firm adjusts H. Because the adjustment cost function of rigid labor has a discontinuous derivative:

$$c_2 = \begin{cases} C, \text{ if } H > (1-\delta_h)\, H_{-1}, \\ -F, \text{ if } H < (1-\delta_h)\, H_{-1}, \\ 0, \text{ if } H = (1-\delta_h)\, H_{-1}, \end{cases}$$

adjustments in rigid labor yield two possible solutions:

$$\begin{aligned} H_C &= \left\{ H \left| \widetilde{E}V_H = -\widetilde{E}V_{K'}\, D_H|_{c_2=C} \right. \right\}, \text{ if } H > (1-\delta_h)\, H_{-1}, \\ H_F &= \left\{ H \left| \widetilde{E}V_H = -\widetilde{E}V_{K'}\, D_H|_{c_2=-F} \right. \right\}, \text{ if } H < (1-\delta_h)\, H_{-1}. \end{aligned}$$

And given that $D_H|_{c_2=-F} > D_H|_{c_2=C}$, then $H_F > H_C$, and the solution for rigid labor is selected in the following way:

$$H = \begin{cases} H_C, \text{ if } H_C > (1-\delta_h)\, H_{-1}, \\ H_F, \text{ if } H_F < (1-\delta_h)\, H_{-1}, \text{ and} \\ (1-\delta_h)\, H_{-1}, \text{ if } H_C < (1-\delta_h)\, H_{-1} < H_F. \end{cases}$$

Certainly, this solution depends on the state variables and is determined simultaneously with capital and debt. A shorter expression for this solution is

$$H = \min\left(\max\left((1-\delta_h)\, H_{-1}, H_C\right), H_F\right). \tag{7}$$

Now, we can combine the first order conditions that apply and write down the three equations that determine capital, debt and rigid labor. Binding dividend and debt constraints give rise to three possible regimes:

Regime I: $y_D > 0$ and $y_{B'} = 0$;

Regime II: $y_D > 0$ and $y_{B'} > 0$;

Regime III: $y_D = 0$ and $y_{B'} > 0$.

There is no Regime IV: at least one constraint must be binding.

Proposition 1 *A firm cannot simultaneously incur debt and issue positive dividends, that is, it cannot be the case that* $y_B = 0$ *and* $y_D = 0$. *Proof: In Appendix B.1.*

The three regimes are then summarized by three equations:

Equation	Regime I	Regime II	Regime III
1.	$D = \overline{D}$		$\widetilde{E}V_{K'} = 1 + \rho$
2.	$\widetilde{E}V_{K'} = -\widetilde{E}V_{B'}$	$B' = 0$	
3.	$H = \min\left(\max\left(\left(1-\delta_h\right)H_{-1}, H_C\right), H_F\right)$		

Once the solution is found, one can determine the Lagrange multipliers:

Multiplier	Regime I	Regime II	Regime III
$y_D =$	$-1 + \frac{1}{1+\rho}\widetilde{E}V_{K'}$		0
$y_B =$	0	$-\frac{1}{1+\rho}\left(\widetilde{E}V_{K'} + \widetilde{E}V_{B'}\right)$	

Since this model does not admit an analytical solution, the solution has to be approximated by numerical methods. It will prove useful both for solving the model numerically and for gaining further insights on the optimal solution, to understand the relationship that capital, debt and internal resources maintain at the optimum in each regime. These are

Regime I: $B' = K' - x + \overline{D} > 0$, $K' > x - \overline{D}$;

Regime II: $B' = 0$, $K' = x - \overline{D}$;

Regime III: $B' = 0$, $K' < x - \overline{D}$.

This means that in general the optimal solution for debt is

$$B' = \max\left(K' - x + \overline{D}, 0\right). \tag{8}$$

Let the pairs $\left(K^I, H^I\right)$ and $\left(K^{III}, H^{III}\right)$ be the optimal solutions for capital and rigid labor in Regime I and Regime III, respectively. In Regime I, with a binding dividend constraint, all state variables determine the solution, thus:

$$\begin{aligned} K^I &\equiv K^I\left(K, H_{-1}, (1+r)B, \theta\right), \\ H^I &\equiv H^I\left(K, H_{-1}, (1+r)B, \theta\right). \end{aligned}$$

And given that in Regime III the dividend constraint does not bind, only lagged rigid labor through of the adjustment cost and current productivity determine the optimal solution:

$$\begin{aligned} K^{III} &\equiv K^{III}\left(H_{-1}, \theta\right), \\ H^{III} &\equiv H^{III}\left(H_{-1}, \theta\right). \end{aligned}$$

Let $\overline{K}$ be the level of optimal capital in Regime I that sets debt equal to zero:

$$\overline{K} = \left\{ K^I \middle| K^I = x - \overline{D} \right\}, \tag{9}$$

then in Regime II capital and labor are:

$$\begin{aligned} K^{II} &\equiv x|_{H^{II}} - \overline{D}, \\ H^{II} &\equiv H^{II}\left(K, H_{-1}, (1+r)B, \theta\right). \end{aligned}$$

In these equations, rigid labor is determined, simultaneously with capital, from Eq.(7), where H_F and H_C depend on the state variables and capital for each Regime. In general the optimal solution for capital can be written as

$$K' = \min\left(\max\left(K^I, x - \overline{D}\right), K^{III}\right). \tag{10}$$

Figure 1b illustrates the optimal solution for K' and B' as a function of x. The three regimes are clearly distinguished: in Regime I capital is increasing and debt is positive; in Regime II capital is increasing and debt is zero; in Regime III capital is a constant and debt is zero. Figure 1c illustrates the optimal solution for H as a function of H_{-1}. In models of adjustment costs under free capital markets, firms with a level of rigid labor lower than H_C adjust to H_C, whereas firms with a level of rigid labor higher than H_F adjust to H_F. However, under financial constraints firms that are financially poor may not afford to pay the adjustment cost. This implies that firms that want to hire workers only hire to a level below H_C, and firms that want to fire workers can only reduce their rigid labor to a level above H_F.

The following table summarizes the relationships that capital, debt and internal resources maintain at the optimum in the three regimes:

Variable	Regime I	Regime II	Regime III
x	$x - \overline{D} < \overline{K}$	$\overline{K} \leq x - \overline{D} \leq K^{III}$	$x - \overline{D} > K^{III}$
K'	K^I	$x - \overline{D}$	K^{III}
B'	$K^I - x + \overline{D}$	0	0

In this setup current rigid labor is a choice variable which, together with the state variables, determines flexible labor and thus the level of internal resources. Therefore, this table is only informative about the relationship that choice variables maintain at the optimum. In models of investment without labor or with labor in perfect labor markets, internal resources x become a state variable themselves, in which case this table would summarize the optimal solution. Figure 1d show how x depends on lagged rigid labor H_{-1}. Entering the period with too few or too many rigid workers is a liability for the firm as it has to pay hiring or firing costs, respectively, to reach its optimal level of rigid workers. These costs thus create persistence in the number of rigid workers and link this number with the financial position of the firm: a lack or an excess of rigid workers are both a sign that the firm's internal resources are low.

3.4 Sequential Solution

Having characterized the optimal solution, for computational purposes it is convenient to rewrite the problem as a sequential maximization in two stages and exploit the connections between choice variables found above.

Stage I: Solution for capital and debt conditional on rigid labor.

Conditioning on rigid labor, we maximize the value function over capital, which determines debt B' by Eq. (8) and the interest rate next period r' by Eq. (3). The value function conditional on rigid labor H is then:

$$W(x, \theta; H) = \max_{K'} \left\{ \max\left(x - K', \overline{D}\right) + \frac{1}{1+\rho} E \max\left[V(K', H, (1+r')\, B', \theta'), 0\right] \right\}.$$

In this maximization there is no need for Lagrange multipliers, because Eq. (8), implying that current dividends are $\max\left(x - K', \overline{D}\right)$, takes care of the dividend and the debt constraints. The solution for this problem is contained in the policy rule $K^w(x, \theta; H)$. Optimal debt is obtained from this solution and Eq. (8).

Stage II: Solution for rigid labor

Using Eq. (6) and Eq. (4) we map the state variables $(K, H_{-1}, (1+r)\, B, \theta)$ and rigid labor H to internal resources and maximize the function found in the previous stage over rigid labor:

$$V(K, H_{-1}, (1+r)\, B, \theta) = \max_{H} W(x, \theta; H).$$

The corresponding solution is the policy rule $H^* \equiv H(K, H_{-1}, (1+r)\, B, \theta)$, which determines

$L^* \equiv L^*(K, H_{-1}, (1+r)\, B, \theta) = L(K, H^*, \theta)$, optimal flexible labor, from Eq. (6);

x^*, defined as internal resources at the optimum, from Eq. (4);

$K^* \equiv K^*(K, H_{-1}, (1+r)\, B, \theta) = K^w(x^*, \theta; H^*)$, optimal capital next period, from mapping optimal rigid labor to the solution of the previous stage;

$B^* \equiv B^*(K, H_{-1}, (1+r)\, B, \theta) = \max\left(K^* - x^* + \overline{D}, 0\right)$, optimal debt next period, from Eq. (8).

I compute a numerical solution for assigned parameter values by discretizing the state space, that is, all possible combinations of K, H, and $(1+r)\, B$, into a grid of points. This procedure is explained in greater detail in Appendix A2. Notice that Eqs (6) and (8) are used to solve for two instead of four choice variables and that the sequential solution is faster than a simultaneous one.[4]

[4] To simplify the argument assume that all loops executed in the numerical solution have the same size N, an integer. Then, the sequential maximization (three states and one choice plus four states and one choice) is clearly faster is than the simultaneous one (four states and two choices), as $N^5 + N^4 < N^6$, if $N \geq 2$.

4 Data

The data come from balance sheet records kept at the Bank of Spain (Central de Balances del Banco de España - CBBE). This dataset contains 94192 observations for more than 200 variables about the financial structure as well as employment of 19473 firms from 1983 until 1996. I conducted a selection of the data, leaving in the sample manufacturing private firms that do not change activity, do not merge or split and have more than five consecutive observations. I also excluded firms with observations that have negative or zero gross capital formation. The final sample consists of 1217 firms with 10787 observations. The employment information is given in terms of permanent and temporary workers, which correspond to the categories of rigid and permanent labor, respectively. A further description of the selection of the data, the definition of the variables and the structure of the panel is provided in Appendix A3.

[Insert Table 1 here]

Table 1 presents descriptive statistics for the main variables in original amounts, ratios and variations. The data for capital and debt are given in millions of pesetas of 1987, computed using the industrial price index. This table gives an idea about the values of the variables by size, measured as thirds in the distribution of capital, and by period: before the labor market reform (1982-1983), up to six years after the reform (1984-1989), and 1990-1996. This period is characterized by an important growth of capital, 3.3% by year, being the growth rate higher between 1984 and 1989, and a decline of debt. Notice that in relative terms debt by worker is higher for the medium sized firms, whereas the debt-capital ratio is monotonically decreasing in firms' size. As predicted by the model, firms with a high level of capital rely less on debt for their financial needs than small firms, which may be thirsty for financial resources.

In this same period, flexible labor substitutes rigid labor, and, moreover, experiences a very high expansion, which is responsible for most of the expansion in total labor in the eighties and nineties. It is noteworthy that after 1984 small and large firms have a lower percentage of flexible labor over the total labor force than medium sized firms. According to the theoretical model, firms with little capital demand relatively less of either type of labor, while firms with large capital levels can afford to pay the labor adjustment costs and hire more rigid labor. Graphical evidence and further discussion of these trends is provided in Section 6, which compares actual and predicted paths of all these variables.

5 Estimation

The estimation consists of using the policy rules of the theoretical model as an input in a maximum likelihood estimation. In the next subsections I explain the way that the estimation procedure accounts for the introduction of flexible labor in 1984, the construction of the likelihood contributions, and the likelihood function maximization.

5.1 The 1984 Labor Market Reform

Because the sample starts in 1983 and ends in 1996, it covers two regimes: one with and one without flexible labor. In the estimation procedure, this is accounted for as an unanticipated regime change, so that

$$\begin{aligned} \text{Regime wihout flexible labor} &: \quad t \leq 1984, \\ \text{Regime with flexible labor} &: \quad t > 1984. \end{aligned}$$

I solve the dynamic programming problem two times, one for each regime: policy rules that match data up to 1984 exclude flexible labor as a choice; policy rules that match data after 1984 do include flexible labor as a choice.

5.2 Likelihood function

The log-likelihood function is the sum of the log of each firm's joint density of the sequence of observed capital, rigid and flexible labor, and debt, conditional on the first observation of capital and debt:

$$\ln \mathcal{L} \left(\Theta | K_1^{obs}, B_1^{obs} \right) = \sum_{i=1}^{N} \sum_{t=1}^{T_i} \ln \mathcal{L}_{it}, \tag{11}$$

where $\mathcal{L}_{it}$ is the likelihood contribution of firm i at time t and Θ is the parameter set. The estimated parameter set is defined as

$$\widehat{\Theta} = \arg\max \ln \mathcal{L} \left(\Theta | K_1^{obs}, B_1^{obs} \right)$$

If the random process for productivity in the theoretical model accounts for all observed variables, the construction of the individual period-specific likelihood contributions is straightforward. In that case, the likelihood contribution for period t

(dropping individual subscripts to improve legibility) is

$$\mathcal{L}_t = \widehat{\psi}_t \frac{1}{\sigma}\phi\left(\frac{\theta_t - \gamma\theta_{t-1} - \mu}{\sigma}\right),\ t = 1, ..., T_i,$$

where $\widehat{\psi}_{it} = 1$, if the model predicted variables coincide with the observables, and $\widehat{\psi}_{it} = 0$, otherwise. Three cases are possible

Initial period, $t = 1$**:** Since the first observations of capital and debt are not predicted by the model, as in other panel data estimations, it is assumed that $K_1 = K_1^{obs}$ and $B_1 = B_1^{obs}$. For $\widehat{\psi}_t$ to be one, observables K_2^{obs}, B_2^{obs}, H_1^{obs}, and L_1^{obs} have to be produced by the state variables K_1, H_0, $(1 + r_1) B_1$, θ_1. However, we do not observe θ_1, H_0 and r_1. Because we can recover the interest rate from the function $r_1 (K_1, H_0, B_1, \theta_0)$, we need to find the values of H_0, θ_0, and θ_1 that yield the observables. Finding these values means also determining the interest rate $r_2 (K_2, H_1, B_2, \theta_1)$ at which the firm contracts debt B_2^{obs}.

Intermediate periods, $t = 2, ..., T - 1$**:** Once we know the values of K_t, H_{t-1}, B_t, r_t, we just need to find the productivity θ_t that yields K_{t+1}^{obs}, B_{t+1}^{obs}, H_t^{obs}, L_t^{obs}. This productivity also gives us $r_{t+1} (K_t, H_{t-1}, B_t, \theta_t)$.

Last period, $t = T$**:** At the last period, we only need to account for the last observations of labor. Therefore, we only need to find θ_T such that $H_T^{obs} = H_T (K_T, H_{T-1}, (1 + r_T) B_T, \theta_T)$, and $L_T^{obs} = L_T (K_T, H_{T-1}, (1 + r_T) B_T, \theta_T)$.

In the construction of the likelihood contributions, besides accounting for all observables (except for the first observation of capital and debt), we obtain rigid labor H_0 and the sequences of unobservable productivities $\{\theta_t\}_{t=0}^T$ and interest rates $\{r_t\}_{t=1}^T$.

A general way of expressing the construction of $\widehat{\psi}_t$ is

$$\widehat{\psi}_t = \begin{cases} \max_{H_0, \theta_0, \theta_1} \psi_t, & \text{if } t = 1, \text{ and} \\ \max_{\theta_t} \psi_t, & \text{if } t = 2, ..., T, \end{cases}$$

where

$$\psi_t = \begin{cases} g\left(H_t^{obs} - H_t\right) g\left(L_t^{obs} - L_t\right) g\left(K_{t+1}^{obs} - K_{t+1}\right) g\left(B_{t+1}^{obs} - B_{t+1}\right), \text{ if } t = 1, ..T - 1, \text{ and} \\ g\left(H_t^{obs} - H_t\right) g\left(L_t^{obs} - L_t\right), \text{ if } t = T. \end{cases}$$

A strict condition for the likelihood function not to become zero is that $\widehat{\psi}_t = 1$, for all $t = 1, 2, ..., T$, which implies that $g\left(Y_t^{obs} - Y_t\right) = 1\left(Y_t^{obs} - Y_t = 0\right)$, $Y = K, B, H, L$. However, with only one source of randomness in the model it is unlikely that the likelihood function does not collapse. Even if the data were generated by the theoretical model, initial parameters would not account for the sequence of observables. The solutions proposed in the literature consist in adding extra sources of randomness, typically measurement errors, which are introduced in the likelihood computation, not in the theoretical model (Flinn and Heckman 1982, Wolpin 1987), or extra random variables in the theoretical model, such as choice-specific shocks, usually following an extreme-value distribution (Rust 1988).

The solution proposed here is to replace the requirement of choosing the unobserved productivities that produce zero distance between observed and predicted variables by a milder requirement: choosing the unobserved productivities that minimize the distance between the observed variables and the variables predicted by the dynamic programming model. This way, whenever the observed variables do not coincide with their predicted levels, the likelihood value does not become zero but shrinks by a value that is proportional to the distance between the predicted variables and their observable counterparts. Since minimizing the distance at each iteration is equivalent to maximizing the likelihood of occurrence at each observation, let

$$g\left(Y_t^{obs} - Y_t\right) = \frac{1}{\sigma_Y}\phi\left(\frac{Y_t^{obs} - Y_t}{\sigma_Y}\right),$$

where σ_Y for $Y = K, B, H, L$ measures the distance between observed and predicted variables. Thus, this procedure is basically a smoothed version of the estimation without any additional source of randomness in the theoretical model. It does not collapse and allows to recover a sequence of predicted variables, observables and unobservables:$\{K_t\}_{t=1}^{T+1}$, $\{B_t\}_{t=1}^{T+1}$, $\{H_t\}_{t=0}^{T}$, $\{L_t\}_{t=1}^{T}$, $\{\theta_t\}_{t=0}^{T}$, $\{r_t\}_{t=1}^{T}$. Any analysis of counterfactual outcomes can use the sequence of productivities to generate alternative sequences of observables. Moreover, if the model is well specified, maximization of the likelihood function should produce a perfect prediction of the observables by the model, that is, σ_Y measure misspecification.

The set of parameters to be estimated is $\Theta = \{\alpha, \beta, \delta, \gamma, \lambda, \rho, w_H, w_L, C, F, \phi, \mu, \sigma, \overline{D}, \sigma_K, \sigma_H, \sigma_L, \sigma_B\}$, that is, the behavioral parameters and the standard deviations of the predicted errors. For the computation of this likelihood function, I exploit the discretization of the variables performed to solve the theoretical model (see Appendix

A4). The likelihood function is maximized using the Powell algorithm (Press et al. 1992) which uses direction set methods to find the maximum. This algorithm relies on function evaluations, not gradient methods.

6 Results

6.1 Parameters

Table 2 reports the maximum likelihood parameter estimates and the corresponding asymptotic standard errors for two specifications: one when all parameters are estimated and a second one restricting some parameter values. In the first estimation, some parameters are estimated at implausible values, notably firing costs, which are much higher than the values usually observed as severance payments. To correct for this result, which comes from the absence of data on firing costs, I perform a second estimation restricting some parameters, in particular, fixing firing costs to their usual value, almost half of the annual wage rate. This is the firing cost for an 'unfair' dismissal of a worker with three years of tenure.

In the free specification, the capital coefficient is estimated at around 0.26, whereas the labor coefficient is around 0.50. In the restricted specification, the capital coefficient remains practically unchanged, but the labor coefficient increases to 0.64. These Cobb-Douglas parameters display decreasing returns to scale. The fact that both results imply that $\gamma>\beta$ indicates sustitutability between the two types of labor. In the restricted model, γ increases from 0.74 to 0.83, maintaining the substitution between the two types of labor. The estimate for λ is around 0.20 in both models, that is, flexible labor is around 20% as productive rigid labor.

[Insert Table 2 here]

The depreciation parameter for capital of around 0.16 in both specifications is in line with previous research, whereas the rate of quits of rigid labor is 0.0054. Variations in rigid labor do not rely on quits, but on the firms' decisions. Wage rates of 2.0581 for rigid labor and of 0.6987 for flexible labor correspond respectively to average and minimum wages per annum in Spain. As explained above, in the unrestricted model, firing costs are high with respect to observed severance payments, but they have to be interpreted as the total cost the employer has to pay for reducing rigid labor. The risk-free interest rate estimated at 4.22% per annum coincides with the observed one during the sample period. The autocorrelation parameter of the productivity process is 0.88 in the unrestricted specification and 0.79 in the restricted version. The lower threshold on dividends is estimated at around 100 in the unrestricted model and around 50 in the restricted model. Clearly, imposing lower firing and hiring costs produces a reduction of the drift and volality of the productivity process and a tighter dividend constraint. The standard deviation of the predicted errors are low compared to the standard deviation of the four variables explained in the descriptive section; they also coincide roughly with the implied sample standard deviations. Given that asymptotic standard errors are very low, in the next subsections I provide an assessment of the *restricted* model's ability to fit the data.[5]

6.2 Graphical Comparison

Figure 2 reports the paths for actual and predicted average capital, debt, and rigid and flexible labor by year. The model displays good replication of the data, especially of capital and permanent labor. The predicted path for debt fluctuates around the actual one; however, it overpredicts debt in the first years of the sample and it underpredicts it in the last years. This looks clearer in Figure 2c, which shows the debt-capital ratio over time. There is an increase in this ratio from 1983 until 1985 and from then onwards a decrease. Predicted flexible labor in the first two years is zero, because in these years the model does not admit flexible labor as a choice. In the years thereafter predicted flexible labor grows relatively faster than the actual one and the gap between this actual and predicted variable narrows down. This trend is also clear in Figure 2d showing the actual and predicted percentage of temporary labor over the total labor force. These graphs are illustrative on the success of the model in replicating the data; a more accurate assessment is provided in the following subsection.

[Insert Figure 2 here]

[5] I will use the also use the restricted model to assess goodness of fit and to evaluate counterfactual scenarios. As firing costs are very high under the unrestricted specification, experiments on counterfactual scenarios produce the same qualitative results but with stronger variations in employment and investment. The interested reader is welcome to request results based on the unrestricted model from the author.

6.3 Goodness of Fit

To assess if the parameter estimates capture the essential features of the data, I compare the observed and the predicted choice distributions of capital, debt and the two types of labor. I perform goodness of fit tests to evaluate if the distribution of the data can be produced by the theoretical model at the estimated parameters. The test statistic across choices j at time t is defined as $\chi_t^2 = \Sigma_{j=1}^{J} \frac{(n_{jt}-\hat{n}_{jt})^2}{\hat{n}_{jt}}$, where n_{jt} is the actual number of observations of choice j at time t, $\hat{n}_{jt}$ be the model predicted counterpart, J is the total number of possible choices and T is the number of years. This statistic has an asymptotic χ^2 distribution with $J-1$ degrees of freedom. To construct this statistic, I divide capital stock, debt and the two types of labor into five quintiles each, that is, $J = 5$.

Additionally, I report the R^2 statistic defined as

$$R^2 = \frac{\sum \widehat{Y}^2}{\sum Y_{obs}^2},$$

where Y_{obs} is the observed and $\widehat{Y}$ is the predicted variable (capital, debt, and the two types of labor). Unlike in the linear regression framework, this statistic is not bounded between zero and one.[6]

[Insert Table 3a and Table 3b here]

Table 3a and Table 3b reports the actual and predicted averages, the χ_t^2 and R^2 statistics by variable and by year. The average and predicted variables were used to construct the graphs discussed in he previous subsection. The χ_t^2 statistic of capital and debt for the first year are zero because the model predicted distribution is generated using the first observation on capital and debt in the data. As in the graphical comparison, the model fit for capital and rigid labor is good. However, the model does not fit the debt data so well, yet the χ^2 statistics fall below the critical value at a 5% of significance, except in year 1986 and 1987. For flexible labor, in spite of the systematic average underprediction of the model, the χ^2 statistic is significant for all years. The R^2 statistic shows the same figure: while capital capital and rigid labor exhibit an R^2 statistic above 0.95, this statistic is around 0.5 for debt and 0.13 for flexible labor.

[6] Let the predicted errors be $e = Y_{obs} - \widehat{Y}$. Squaring and summing across observations, one obtains $\sum Y_{obs}^2 = \sum \widehat{Y}^2 + 2\sum \widehat{Y}e + \sum e^2$. As it is not necessarily true that $\sum \widehat{Y}e = 0$, the R^2 statistic is not bounded between zero and one.

I also report the sample standard deviations of the predicted errors of each variable in the last row of each table. Notice that they are very close to those estimated in the maximum likelihood procedure: σ_K, σ_H, σ_L, σ_B.

7 Regime Changes

Having recovered the underlying parameters of the model and assessed its success in replicating the data, I perform some regime changes. Starting off with the true values 1983 and 1984 and simulate the paths of the four variables under three counterfactual scenarios from 1985 onwards: (i) there is no labor reform in 1984, that is, there is no flexible labor throughout the sample period; (ii) the reform in 1984 consists in removing labor rigidities fully; and (iii) the reform in 1984 consists in relaxing liquidity constraints. These experiments are useful to quantify the contribution of flexible contracts, labor market rigidities and liquidity constraints in explaining the observed trends in the data. As explained above, I will use the estimated parameters of the restricted model to perform this evaluation. Using the unrestricted model is also feasible, but it exaggerates both the responses of the observed variables to the policy experiments.

To build these counterfactual scenarios I use the sequence of predicted productivity levels and the predicted observables in 1983 and 1984. From 1985 onwards I use the policy rules that solve the theoretical model evaluated at parameter set that corresponds to the new regime. The sequences of new predictions are reported in Table 4 and depicted in Figure d.

[Insert Table 4a, Table 4b and Figure 3 here]

7.1 No Flexible Labor

Figure 3a and Figure 3b graph the actual and predicted paths of the four variables, if there had been not labor reform in 1984. The numerical values are presented in the second column of Table 4 for each variable, corresponding to the sequence under liquidity constraints, labor market rigidities and no flexible labor. It is clear that the observed reform did not provoke any dramatic change in any observed variable, except in flexible labor. Had the 1984 labor reform not occurred, in the following years capital and debt levels would have been higher on average and rigid labor would have been lower on average. This indicates that the labor market reform (i) produced substitution from capital to labor, (ii) alleviated liquidity constraints, reducing firms' debt, and (iii) did not reduce rigid labor substantially.

7.2 No Hiring and Firing Costs

Figure 3c and Figure 3d depict the paths of the variables if labor rigidities had been fully removed. This experiment consists in solving the dynamic programming problem using the estimated parameters, except the firing and hiring costs which are set to zero: $C = F = 0$. Removing labor market rigidities would (i) produce a substantial decrease in rigid labor just immediately after the regime change, with a recovery in the years thereafter, (ii) have no substantial effect on debt, and (iii) produce an increase in capital. This reaction is a sign that firms have too much rigid labor, which they would like to get rid off and they cannot because of the high costs that this would represent.

7.3 Free Capital Markets

In the next experiment I assess the effect of relaxing the dividend constraint. This is accomplished setting $\overline{D}$ at a very low level. As shown in Figure 3e and Figure 3f, this regime change implies (i) a substantial increase in capital accumulation, (ii) a substantial reduction in rigid labor followed by a further increase in rigid labor, and (iii) a substantial reduction in debt. This regime change is indicative of the potential for increasing investment in the Spanish economy and shows that removing financial constraints creates more employment than only removing labor market rigidities. Actually, once financial constraints are relaxed, removing firing and hiring costs does not produce different trajectories of the four relevant variables. *Eurosclerosis* can persist under imperfect capital markets. A financial liberalization can activate both the sclerotic labor markets as well as increase investment by a big amount.

8 Conclusions

Using a dynamic model of labor demand under liquidity constraints, I have shown that Spanish firms use flexible contracts to alleviate financial constraints, reducing thereby their level of borrowing. Since creation of permanent jobs is limited by owned financial resources, firms have to improve their financial position to be able to hire more permanent workers, reduce their demand for flexible ones and their need for debt.

A reform that removes labor market rigidities, politically unfeasible in most Western European economies, would allow firms to get rid of unnecessary permanent employment, but it would produce a modest increase in investment and a slow reduction of debt. On the contrary, relaxing financial constraints would produce similar results as in the previous reform, just at a higher level: it would create more permanent employment and produce a big jump in firms' investment as well as a big reduction in borrowing. Policies designed to increase job creation cannot abstract from financial variables and investment and be confined to labor market policy measures; they should also be oriented toward relaxing financial constraints.

Appendix

A1. Model

Endogenous interest rate.- The interest rate solves $G(r') = 0$, which may not yield a unique solution for r' given K', B' and θ as it is not monotonically increasing in r':

$$G'(r') = 1 - \Phi(\kappa') - \frac{1}{\sigma}\phi(\kappa')(1 + r')\underline{\theta}'_{r'}$$

When there are multiple solutions, competition between lenders will lead to the lowest of these rates. Since $G(\rho) = -\Phi(\kappa')(1+\rho) < 0$, if at least one equilibrium rate exists, there is a low value of r', such that $G'(r') \geq 0$, implying $1 - \Phi(\kappa') \geq \frac{1}{\sigma}\phi(\kappa')(1+r')\underline{\theta}'_{r'}$ and $\Upsilon > 0$. Using the implicit function $G(r')$ we obtain the derivatives of the interest rate function over its arguments shown in the main text.

Proof of Proposition 1 *Suppose that $y_D = 0$ and $y_{B'} = 0$. Plugging these conditions in $Z_{B'}$ one obtains*

$$B' = \frac{-(1+\rho)\left[1 - \Phi(\kappa')\right]\widetilde{E}y'_D}{r'_B\left[1 - \Phi(\kappa') + \widetilde{E}y'_D\right]} < 0,$$

that is, debt would be negative which violates the non-negativity constraint on debt.■

A2. Numerical Solution

Discretization

The following table provides the relevant information about the discretization of the variables.

Discretization of variables

Original variable	Discretized variable	Grid of points	Number of gridpoints	Lower Bound	Upper Bound
x	$x(m)$	$m = 1, ..., N_x$	$N_x = 151$	-6000	6000
θ	$\theta(s)$	$s = 1, ..., N_\theta$	$N_\theta = 11$	$\mu_\theta - 3\sigma_\theta$	$\mu_\theta + 3\sigma_\theta$
K	$K(k)$	$k = 0, ..., N_K$	$N_K = 31$	0	3000
B	$B(j)$	$j = 0, ..., N_B$	$N_B = 51$	0	1000
$B(1+r)$	$\widetilde{B}(i)$	$i = 0, ..., N_{\widetilde{B}}$	$N_{\widetilde{B}} = 51$	0	2000
H	$H(h)$	$h = 0, ..., N_H$	$N_H = 31$	0	1000
L	$L(l)$	$l = 0, ..., N_L$	$N_L = 1352$	0	1350

The gridsize of each variable is the segment between the variable's upper and lower bound divided the number of gridpoints.[7]

The mean and the variance of productivity θ, which follows an AR(1) process,

[7] For K, B, $\widetilde{B}$, H, and L the gridsize is the segment between the upper and lower bound divided by the number of gridpoints minus one. Ordinals from one to N are assigned to the gridpoints, while the ordinal zero is reserved to express $K(0) = B(0) = \widetilde{B}(0) = H(0) = L(0) = 0$.

are $\mu_\theta = \frac{\mu}{1-\rho}$ and $\sigma_\theta = \frac{\sigma}{\sqrt{1-\rho^2}}$; its probability distribution function is also discretized:

$$g\left(s'|s\right) = \Pr(s'|s) = \Phi\left(\frac{\theta(s') - \gamma\theta(s) + \Delta/2 - \mu}{\sigma}\right) - \Phi\left(\frac{\theta(s') - \gamma\theta(s) - \Delta/2 - \mu}{\sigma}\right)$$

where the gridsize is $\Delta = \frac{6\sigma}{N_\theta}$.

Solving the DP-problem

1. Compute the static rules for L, B', and x.

   Flexible labor: For each combination $K(k)$, $H(h)$, $\theta(s)$ find the root of Eq. (6) and assign it to its discrete counterpart, that is, $l = l(k,h,s)$. Negative values of L imply that $l = 0$.

   Debt: For each combination $x(m), K'(k')$ find B' from Eq. (8) and assign it to the ordinal $j' = j(m,k')$

   Internal resources: For each combination $K(k)$, $\widetilde{B}(i)$, $H(h)$, $H(h_{-1})$, $L(l)$, $\theta(s)$ find x from Eq. (4) and assign it to the ordinal $m = m(k,i,h,h_{-1},l,s)$.

2. For each combination k', i', h, s' create the array $V_n(k', i', h, s') = 0$, $n = 0$.

3. Find $\underline{s}'(k', i', h) = \arg\min_s V_n(k', i', h, s')$ s. t. $V_n(k', i', h, s') \geq 0$.

4. For each combination k', i', h, s integrate over all admissible values of s:

$$EV(k', i', h, s) = \sum_{s'=\underline{s}'}^{N_\theta} V_n(k', i', h, s')g(s'|s).$$

5. **Equilibrium interest rate.** For each combination k', j', h, s $(j' \neq 0)$

   (a) Compute $\widetilde{B} = B(j')(1+\rho)$, assign it to the ordinal i' and determine $\underline{s}'_0 = \underline{s}'(k', i', h)$.

   (b) Compute $r' = \frac{(1+\rho)}{g\left(\underline{s}'_0|s\right)} - 1$, which comes from Eq. (3).

   (c) Compute $\widetilde{B} = B(j')(1+r')$, assign it to the ordinal i' and determine $\underline{s}'_1(k', i', h)$.

   (d) If $\underline{s}'_1 = \underline{s}'_0$, keep $i' = i'(k', j', h, s)$; otherwise set $\underline{s}'_0 = \underline{s}'_0 + 1$ and go back to b.

   For each combination k', h, s, set $i'(k', 0, h, s) = 0$.

6. For each combination m, s, h construct

$$W(m,s;h) = \max_{k'}\left\{x(m) - K'(k') + B'\left(j'\right) + \frac{1}{1+\rho}EV(k', i', h, s)\right\},$$

   where $j' = j'(m,k')$ and $i = i(k', j', h, s)$.

7. For each combination k, i, h_{-1}, s update V_n:

$$V_n(k, i, h_{-1}, s) = \max_h W(m, s; h),$$

where $m = m(k, i, h, h_{-1}, l, s)$ and $l = l(k, h, s)$.

8. Go to 2, if the tolerance criterion ω is not met, that is, if

$$\max |V_n(k, i, h_{-1}, s) - V_{n-1}(k, i, h_{-1}, s)| > \omega.$$

9. **Policy rules**:

   (a) Repeat 6 and compute the solution $k = k(m, s; h)$ for each combination $m, s; h$.

   (b) Repeat 7 and compute the solution $h^*(k, i, h_{-1}, s) = \arg\max_h W(m, s; h)$, which determines the other policy rules:

$$\begin{aligned} l^*(k, i, h_{-1}, s) &= l(k, h^*, s), \\ k^*(k, i, h_{-1}, s) &= k(m^*, s; h^*), \text{ and} \\ j^*(k, i, h_{-1}, s) &= j(m^*, k^*), \end{aligned}$$

   where $m^* = m(k, i, h^*, h_{-1}, l^*, s)$.

A3. Sample selection

The original information for 94192 observations of 19473 firms. The first section excludes firms that change activity, merge or split, have less than five observations available or that are public or non-manufacturing. These filters leave 27704 observations of 3005 firms in the sample, being the most important selection to exclude non-manufacturing firms, which alone leaves 40738 observations of 7587 firms in the sample. The next most important selection results from leaving out of the sample firms that have at least one observation with a non-positive value of the following variables: value of production, value of net purchases, net fixed assets, gross capital formation, total outside resources-debt with providers, gross value added, net worth, cumulative downpayment, or whose net fixed assets grow more than three times. This selection leaves 10787 observations of 1217 firms in the sample.

The definitions of the variables correspond to the following definitions of the database:

Capital =Net fixed assets;
Debt =Short term debt with cost;
Rigid labor=Number of workers with permanent contracts;
Flexible labor=Number of workers with temporary contracts.

Table A1 shows the structure of the panel by year. There is a relatively fair representation of all periods of interest in the sample. For 568 of the 1217 firms, that is for 48%, there is information before and after the 1984 labor market reform. Table A2 gives an idea of the longitudinal dimension of the panel. There is a relatively large proportion of firms that stay in the sample for a long time: 43% of the firms have 10 or more observations.

[Insert Table A1 and Table A2 here]

A4. Likelihood function

The construction of the likelihood function also exploits the discretization of the continuous variables done to solve the DP problem. The discretized densities used to define ψ are

$$\begin{aligned}\varphi_Y(\iota^{obs},\iota) &= \Phi\left(\frac{Y^{obs}\left(\iota^{obs}\right)-Y\left(\iota\right)+\Delta_Y/2}{\sigma_Y}\right)-\Phi\left(\frac{Y^{obs}\left(\iota^{obs}\right)-Y\left(\iota\right)-\Delta_Y/2}{\sigma_Y}\right),\\ Y &= K,B,H,L;\ \iota=k,j,h,l.\end{aligned}$$

Then, the computation of the likelihood contribution proceeds as follows.

Initial period, $t=1$**:** Assuming that the observations of capital and debt, characterized by the ordinals k_1^{obs} and j_1^{obs}, are the 'true' ones, find out 'true' rigid labor h_0 and productivities s_0 and s_1. Let

$$\begin{aligned}\psi_1 &= \varphi_K\left(k_2^{obs},k_2\right)\varphi_B\left(j_2^{obs},j_2\right)\varphi_H\left(h_1^{obs},h_1\right)\varphi_L\left(l_1^{obs},l_1\right),\\ \text{then } \widehat{\psi}_1 &= \max_{h_0,s_0,s_1}\psi_1 \text{ and } (h_0,s_0,s_1)=\arg\max\psi_1,\end{aligned}$$

where $(k_2,j_2,h_1,l_1)=(k',j',h,l)\left(k_1^{obs},i_1,h_0,s_1\right)$, and $i_1=i'\left(k_1^{obs},j_1^{obs},h_0,s_0\right)$. The likelihood contribution is $\mathcal{L}_1=\widehat{\psi}_1\times g\left(s_1,s_0\right)$ and store the 'true' values k_2, i_2, h_1, and s_1.

Intermediate periods, $t=2,...,T-1$**:** Using the 'true' values of k_t, i_t, and h_{t-1}, determine the current likelihood contribution.

$$\begin{aligned}\text{Let } \psi_t &= \varphi_K\left(k_{t+1}^{obs},k_{t+1}\right)\varphi_B\left(j_{t+1}^{obs},j_{t+1}\right)\varphi_H\left(h_t^{obs},h_t\right)\varphi_L\left(l_t^{obs},l_t\right),\\ \text{then } \widehat{\psi}_t &= \max_{s_t}\psi_t,\text{ and } s_t=\arg\max\psi_t,\end{aligned}$$

where $(k_{t+1},j_{t+1},h_t,l_t)=(k',j',h,l)\left(k_t,i_t,h_{t-1},s_t\right)$, and $i_{t+1}=i'\left(k_{t+1},j_{t+1},h_t,s_t\right)$. Using s_{t-1}, compute the likelihood contribution: $\mathcal{L}_t=\widehat{\psi}_t\times g\left(s_t,s_{t-1}\right)$ and store the 'true' values k_{t+1}, i_{t+1}, h_t, and s_t.

Last Period, $t=T$ **:** There are no more observations for capital and debt next period; the likelihood contribution only accounts for the two types of labor. Using the 'true' values of k_T, i_T, and h_{T-1}, determine the current likelihood contribution. Let

$$\begin{aligned}\psi_T &= \varphi_H\left(h_T^{obs},h_T\right)\varphi_L\left(l_T^{obs},l_T\right),\\ \text{then } \widehat{\psi}_T &= \max_{s_T}\psi_T \text{ and } s_T=\arg\max\psi_T,\end{aligned}$$

where $(h_T,l_T)=(h,l)\left(k_T,i_T,h_{T-1},s_T\right)$. Using s_{T-1}, compute the likelihood contribution $\mathcal{L}_T=\widehat{\psi}_T\times g\left(s_T,s_{T-1}\right)$.

Once the likelihood contributions are computed, take logs and add them up, that is, compute the likelihood function from Eq. (11).

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Table 1: Descriptive Statistics by period and firm size

Variable	All	1982-1983 Small	1982-1983 Med.	1982-1983 Large	1984-1989 Small	1984-1989 Med.	1984-1989 Large	1990-1996 Small	1990-1996 Med.	1990-1996 Large
Obs.	10787	250	346	411	1910	1778	1654	1437	1471	1530
Capital K										
Average	455	36	171	1179	32	164	1127	33	160	1211
St. Dev.	(741)	(21)	(65)	(918)	(20)	(64)	(902)	(21)	(65)	(969)
K/N	3.18	0.68	1.67	3.37	0.80	1.86	3.47	1.07	2.44	4.02
$\Delta K/K$ %	3.3	-5.6	-9.2	-4.9	3.4	5.5	4.7	-1.4	2.3	3.3
Debt B										
Average	207	53	145	459	47	146	427	43	127	443
St. Dev.	(282)	(71)	(176)	(374)	(70)	(176)	(364)	(88)	(162)	(375)
B/N	1.44	1.11	1.68	1.40	1.20	1.67	1.31	1.40	1.92	1.47
B/K	0.45	1.64	1.01	0.42	1.50	0.90	0.38	1.31	0.79	0.37
$\Delta B/B$ %	0.5	15.1	22.5	5.9	-2.2	1.7	0.7	-1.9	0.7	-1.1
Rigid Labor H										
Average	123	51	92	319	34	75	281	24	51	247
St. Dev.	(189)	(42)	(67)	(282)	(29)	(63)	(259)	(24)	(51)	(247)
$\Delta H/H$ %	0.1	-1.8	0.2	-1.2	0.5	0.6	0.7	-2.5	-0.4	-0.3
Flexible Labor L										
Average	21	4	7	18	5	12	42	6	14	54
St. Dev.	(60)	(17)	(23)	(66)	(9)	(25)	(95)	(9)	(22)	(101)
L/N %	15.8	9.2	7.5	5.9	11.2	13.3	12.9	20.1	21.6	17.8
$\%(L=0)$	32.5	61.6	54.3	45.7	47.9	36.5	28.5	28.0	19.8	16.3
$\Delta L/L$ %	6.8	31.4	3.1	21.8	10.0	14.6	18.5	1.9	-0.1	-1.5
Total Labor N										
Average	144	55	99	337	39	87	323	31	65	301
St. Dev.	(220)	(46)	(68)	(297)	(31)	(68)	(300)	(22)	(51)	(319)
$\Delta N/N$ %	1.1	0.5	0.4	-0.1	1.7	2.3	2.7	-1.7	-0.3	-0.5

Note 1. Data on capital and debt are given in million pesetas of 1987.
Note 2. A firm's size is determined by its position in the distribution of capital. Large firms are in the upper third; medium sized firms are in the middle third; and small firms are in the lower third of the distribution of capital.

Table 2: Parameter Estimates for the Unrestricted and the Restricted Model

Parameters	Unrestricted		Restricted	
	Estimates	St. Err.	Estimates	St. Err.
Production function				
α	0.2565	0.0782	0.2567	0.0345
β	0.5053	0.0996	0.6407	0.0176
γ	0.7357	0.2292	0.8332	0.0623
λ	0.1950	0.1021	0.2135	0.0557
Depreciation				
δ_k	0.1565	0.0252	0.1555	0.0493
δ_h	0.0054	0.0013	0.0054	
Wages				
w_h	2.0581	0.1532	2.0581	
w_l	0.6987	0.3325	0.6987	
Adjustment Costs				
F	8.8890	1.3004	1.0111	
C	0.1056	0.0483	0.0100	
Risk-free interest rate				
ρ	0.0422	0.0329	0.0423	0.0031
Stochastic Process				
ϕ	0.8826	0.0978	0.7869	0.1024
μ	1.3229	0.2189	0.8787	0.2331
σ	2.3338	0.4032	0.2935	0.0794
Borrowing Constraint				
$-\overline{D}$	100.1094	7.7664	49.0774	5.0637
Variable's Errors				
σ_K	142.96	5.29	175.40	23.64
σ_B	267.25	19.38	274.99	22.25
σ_H	40.81	4.25	30.27	4.25
σ_L	36.15	2.22	36.02	10.02
Log-Likelihood				
$-\ln \mathcal{L}$		145495.65		163570.92

Table 3a: Actual and Predicted Variables

Year	Capital				Debt			
	Act.	Pred.	χ^2	R^2	Act.	Pred.	χ^2	R^2
1983	597	597	0.00	1.00	240	240	0.00	1.00
1984	511	532	3.62	1.04	258	257	26.55	0.83
1985	450	503	5.57	1.10	244	216	62.55	0.67
1986	401	447	3.79	1.09	201	191	28.93	0.77
1987	395	426	3.18	1.04	187	188	32.73	0.79
1988	401	433	3.69	0.99	183	187	48.16	0.78
1989	423	460	2.17	1.02	186	181	58.99	0.75
1990	451	484	3.86	0.99	204	174	107.42	0.61
1991	477	503	4.71	0.97	222	167	217.65	0.50
1992	475	496	2.32	0.98	223	161	248.95	0.47
1993	471	497	3.76	0.96	210	158	179.39	0.50
1994	466	488	2.01	0.95	199	144	279.26	0.45
1995	485	512	4.02	0.96	197	155	47.96	0.59
1996	531	537	2.26	0.90	198	160	66.97	0.58
$\sqrt{n^{-1}\Sigma e^2}$		126.13				262.38		

Note. The χ^2-statistic is computed using 5 bins. Critical values are: $\chi^2_{(4)} = 9.49$, at 5% significance level, and $\chi^2_{(4)} = 14.86$, at 0.5% significance level.

Table 3b: Actual and Predicted Variables

Year	Rigid Labor				Flexible Labor			
	Act.	Pred.	χ^2	R^2	Act.	Pred.	χ^2	R^2
1983	185	179	0.71	0.94	10	0	0.00	0.00
1984	163	147	3.13	0.88	11	0	0.00	0.00
1985	148	129	2.98	0.86	10	8	9.01	0.26
1986	131	111	5.61	0.86	12	7	0.01	0.23
1987	122	104	4.16	0.86	15	8	0.02	0.13
1988	118	100	4.86	0.87	19	8	0.04	0.10
1989	116	101	3.99	0.89	25	10	0.08	0.08
1990	116	103	8.82	0.91	24	11	0.09	0.11
1991	116	104	2.62	0.92	24	11	0.08	0.13
1992	110	101	2.38	0.92	26	11	0.06	0.10
1993	107	99	2.03	0.97	23	10	0.05	0.10
1994	105	98	0.10	0.98	24	11	0.04	0.11
1995	107	101	1.52	0.98	26	12	0.02	0.13
1996	111	109	0.23	0.96	26	14	0.04	0.13
$\sqrt{n^{-1}\Sigma e^2}$		41.18				35.99		

Note. The χ^2-statistic is computed using 5 bins. Critical values are: $\chi^2_{(4)} = 9.49$, at 5% significance level, and $\chi^2_{(4)} = 14.86$, at 0.5% significance level.

Table 4a: Regime Changes

Year	Capital						Debt					
$-\overline{D}$	$< \infty$				∞		$< \infty$				∞	
C, F	> 0		$= 0$		≥ 0		> 0		$= 0$		≥ 0	
L	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$
1983	597	597	597	597	597	597	240	240	240	240	240	240
1984	532	532	532	532	532	532	257	257	257	257	257	257
1985	503	503	503	503	503	503	216	216	216	216	216	216
1986	447	461	444	423	518	522	191	191	177	172	22	22
1987	426	433	456	455	515	518	188	174	187	186	21	21
1988	433	458	501	483	552	555	187	176	200	191	14	14
1989	460	494	524	510	567	571	181	171	186	180	20	20
1990	484	533	568	557	608	612	174	165	179	182	12	12
1991	503	558	588	573	619	624	167	160	166	166	15	15
1992	496	550	570	556	603	607	161	147	150	150	23	23
1993	497	564	592	570	623	628	158	136	146	143	10	10
1994	488	557	577	558	591	596	144	120	127	127	10	10
1995	512	597	605	585	616	621	155	127	132	129	10	10
1996	537	626	639	626	660	665	160	136	144	144	10	10

Table 4b: Regime Changes

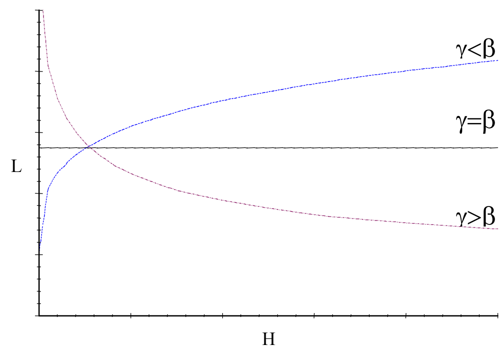
Year	Rigid Labor						Flexible Labor					
$-\overline{D}$	$< \infty$				∞		$< \infty$				∞	
C, F	> 0		$= 0$		≥ 0		> 0		$= 0$		≥ 0	
L	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$	≥ 0	$= 0$
1983	179	179	179	179	179	179	0	0	0	0	0	0
1984	147	147	147	147	147	147	0	0	0	0	0	0
1985	129	126	60	65	60	65	8	0	19	0	19	0
1986	111	106	63	63	69	78	7	0	15	0	21	0
1987	104	98	63	64	72	82	8	0	17	0	20	0
1988	100	95	68	68	73	82	8	0	18	0	23	0
1989	101	100	76	76	82	91	10	0	19	0	23	0
1990	103	104	80	81	86	96	11	0	21	0	24	0
1991	104	106	82	83	87	96	11	0	21	0	25	0
1992	101	104	79	80	86	95	11	0	22	0	25	0
1993	99	101	79	76	84	93	10	0	21	0	25	0
1994	98	104	80	79	81	89	11	0	22	0	26	0
1995	101	110	86	85	89	98	12	0	23	0	26	0
1996	109	136	96	91	107	112	14	0	26	0	22	0

Table A1: Structure of the Panel

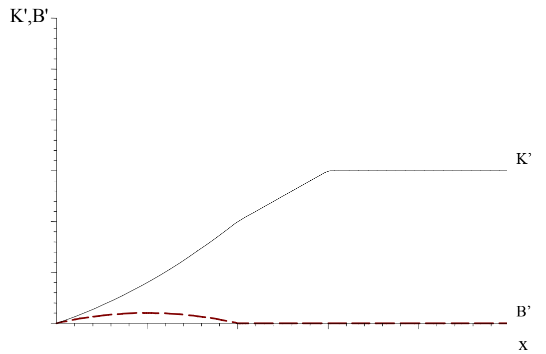
Year	Obs.	Freq.	Cumulative
1983	439	4.07	4.07
1984	568	5.27	9.34
1985	688	6.38	15.71
1986	849	7.87	23.58
1987	964	8.94	32.52
1988	972	9.01	41.53
1989	959	8.89	50.42
1990	910	8.44	58.86
1991	841	7.80	66.65
1992	830	7.69	74.35
1993	767	7.11	81.46
1994	713	6.61	88.07
1995	678	6.29	94.35
1996	609	5.65	100.00
Total	10787	100.00	

Table A2: Balance of the Panel

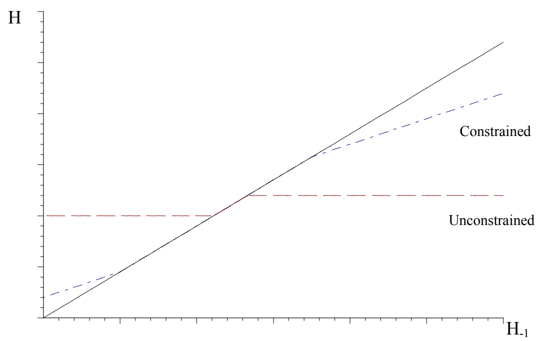
Obs. by firm	Obs.	%	Cum.	Firms	%	Cum.
5	1115	10.34	10.34	223	18.32	18.32
6	1116	10.35	20.68	186	15.28	33.61
7	721	6.68	27.37	103	8.46	42.07
8	864	8.01	35.38	108	8.87	50.94
9	846	7.84	43.22	94	7.72	58.67
10	1000	9.27	52.49	100	8.22	66.89
11	1166	10.81	63.30	106	8.71	75.60
12	852	7.90	71.20	71	5.83	81.43
13	741	6.87	78.07	57	4.68	86.11
14	2366	21.93	100.00	169	13.89	100.00
Total	10787	100.00		1217	100.00	



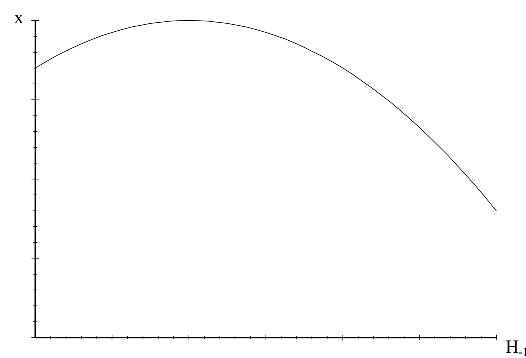
1a: L as a function of H



1b: K' and B' as a function of x



1c: H as a function H_{-1}



1d: x as a function of H_{-1}

Figure 1: Policy Rules for i. Flexible Labor, ii. Capital and Debt, and iii. Rigid Labor; iv. Mapping of H_{-1} on x.

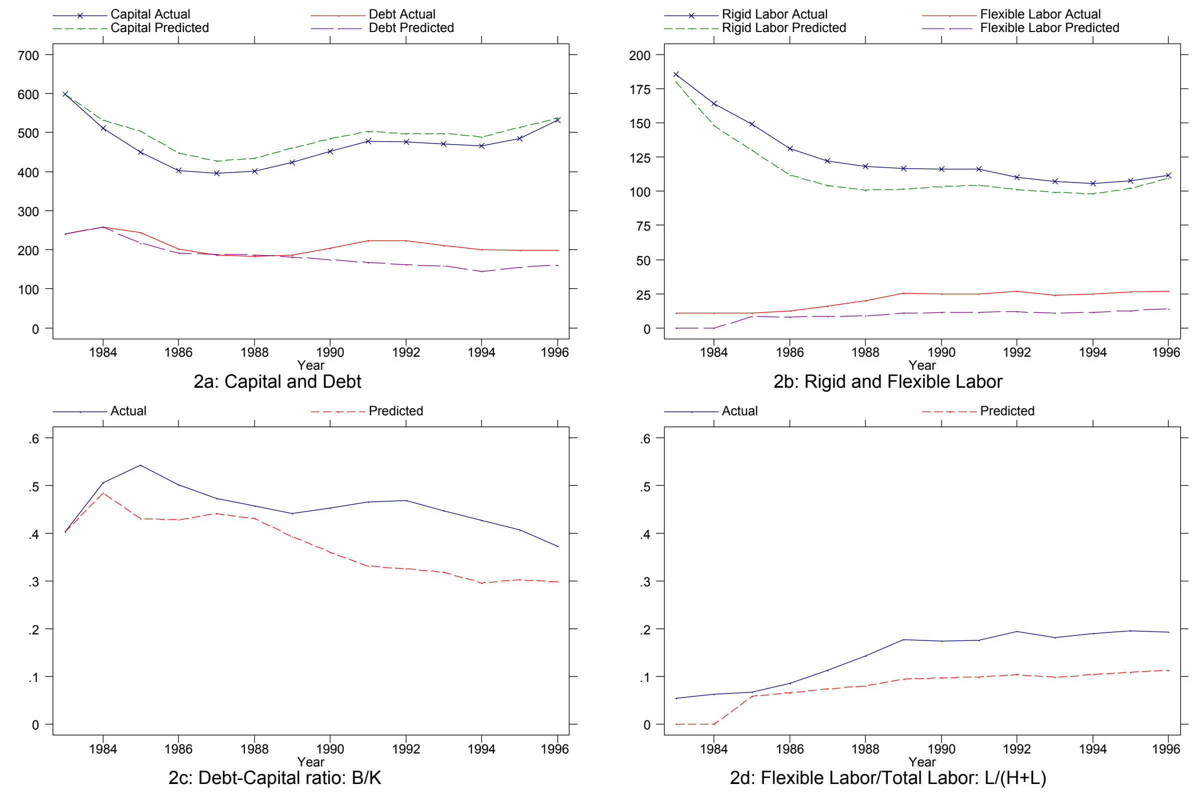


Figure 2: Actual and Predicted Variables

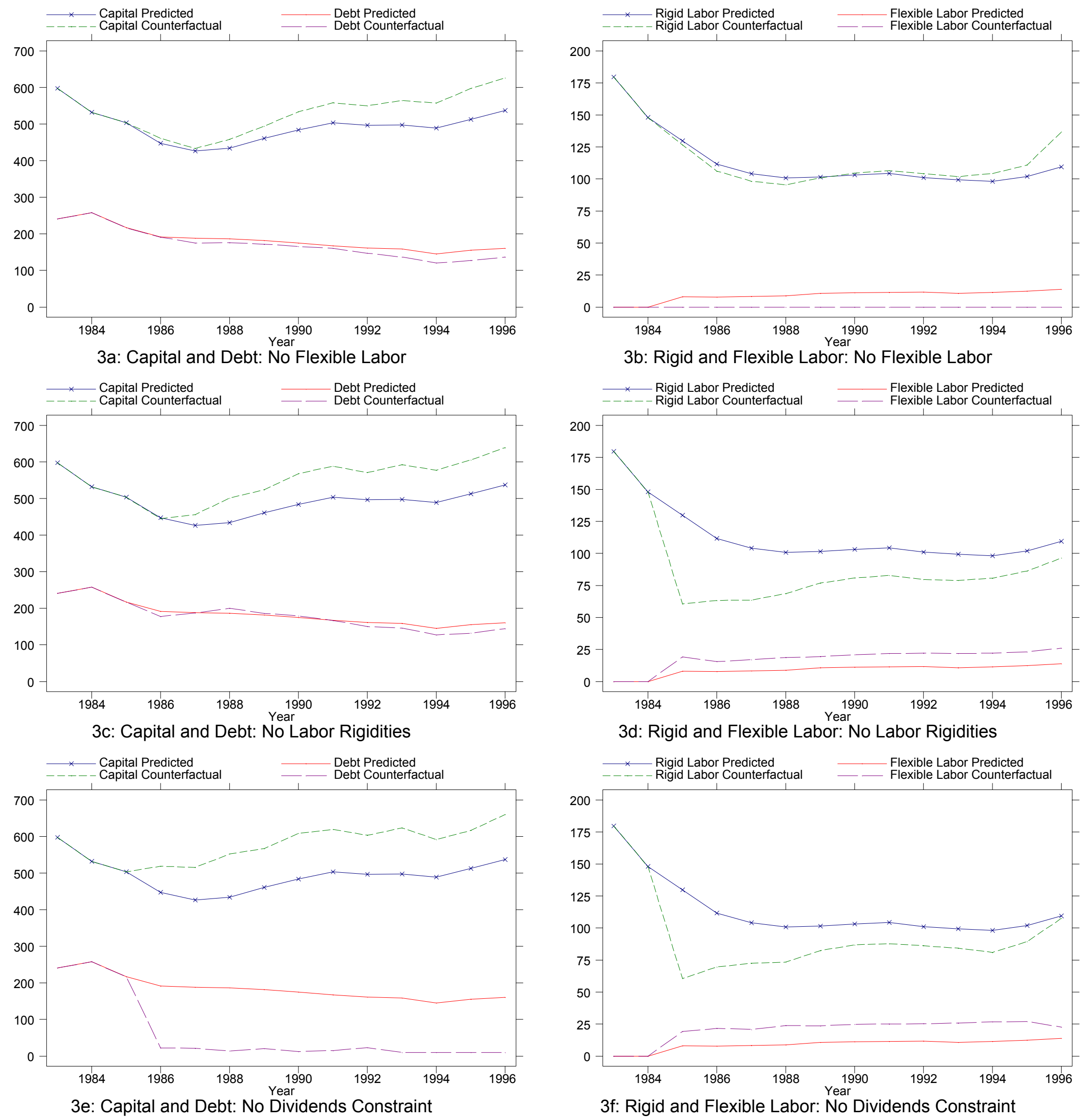


Figure 3: Capital, Debt, and Labor after Regime Changes: (i) No Flexible Labor, (ii) No Labor Rigidities, (iii) No Dividends Constraint