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THE ROLE OF LABOR MARKETS IN STRUCTURAL CHANGE

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Resumen

¿Por qué los servicios se han convertido en el sector predominante en las economías industrializadas? Si bien existe abundante literatura acerca de la transición desde la agricultura hacia la industria (conocida como revolución industrial), no existe una explicación de consenso para la segunda ola de cambio estructural. Este estudio argumenta que diferencias sectoriales en la regulación que afectan el grado de competencia en los mercados del trabajo y de bienes, explican: (a) el aumento de la participación del sector servicios en la producción y el empleo, (b) las diferencias internacionales en cuanto a la estructura de las economías, y (c) los cambios en salarios relativos entre sectores. Usando evidencia de la presencia de imperfecciones en los mercados, se calibra un modelo con dos sectores donde los sindicatos de trabajadores negocian salarios con las empresas. El sector menos competitivo paga salarios más altos y restringe el empleo consistentemente. El modelo produce series de tiempo que son coherentes con la “revolución de los servicios” experimentada en Estados Unidos y Europa entre los años 1950 y 2000. En particular, genera cambios en las participaciones en la producción y el empleo, y ofrece una explicación para las diferencias salariales entre sectores, que no son capturadas por otros estudios.

Abstract

Why did services become the dominant sector in industrialized economies? While abundant literature exists on the transition from agriculture to industry (i.e., the industrial revolution), there is no consensual explanation for the second wave of structural change. I argue that sectoral differences in regulation affecting the degree of competition in labor and goods markets explain: (a) the rise in the services sector share of output and employment, (b) international differences in cross-sector structure, and (c) changes in relative wages among sectors. Using evidence on market imperfections, I calibrate a two-sector model where household unions bargain with firms for wages. The least competitive sector pays higher wages, and employment is restricted accordingly. The model produces time series consistent with the “service revolution” as experienced in the United States and European economies between 1950 and 2000. In particular, while generating changes in shares of output and employment, the model offers an explanation for relative wage differences, which the standard literature fails to capture.

I want to thank the participants of the Trade and Development Workshop at the University of Minnesota, in particular Tim Kehoe, Cristina Arellano and Fabrizio Perri, for their comments. Enriching discussions with Terry Roe, Radek Stefanski, and Le Wang contributed to the completion of this document. This project was completed under financial support of the Minnesota Population Center / IPUMS-I project. All remaining errors are mine. Contact: Gerencia de Análisis Macroeconómico, División de Estudios, Banco Central de Chile, Agustinas 1180, Santiago, Chile. E-mail: mricaurte@bcentral.cl

1 Introduction

During the second half of the twentieth century, industrialized nations evolved from manufacturing -based to service-based economies. This wave of transformation of the productive structure is characterized by an increase in the service sector's share of employment and changes in sectoral employment compensation. It is well documented that while jobs in manufacturing industries fluctuated between 15 and 18 million workers in the 1950-2005 period, the number of jobs in the service sector industries grew from just over 25 million in 1950 to over 100 million in 2005 – a 291% increase. In other words, the net creation of jobs happened in the service sector (see Figure 1.1).

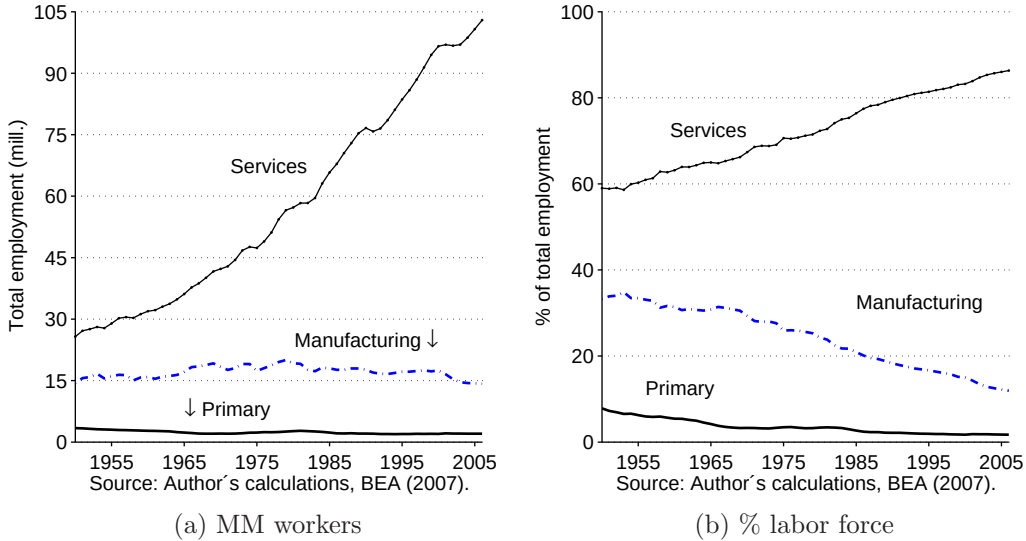


Figure 1.1: Sectoral employment

On the other hand, changes in employment compensation are less well understood in the context of structural transformation. The average wage per worker in manufacturing¹ was higher than in services and increased relative to this sector between 1950 and 2000 (Figure 1.2a). However, when corrected for individual characteristics (see discussion in Section 2 and Appendix B.1), relative wages showed an overall decreasing trend between 1962 and 2008 (Figure 1.2b). These two observations suggest that increasing average wages are the product

¹Measured as (wage accruals + employer's contribution to health and retirement funds + proprietor's income)/ workers in each sector. See Appendix A.3 for details.

of improvements in the quality of labor in manufacturing. Moreover, the occurrence of these trends is incompatible with competitive labor markets.

Therefore, to analyze sectoral employment and wages, I develop a two sector growth model with imperfect labor markets. Like Blanchard and Giavazzi (2003) and Messina (2006), I examine the impact of market regulations on the behavior of households and firms in the context of structural change. In this paper, households which are heterogeneous in terms of productivity, choose between working in the more competitive sector (*i.e.*, services in the United States) and the least competitive one. The incentive to switch to the latter (*i.e.*, manufacturing in the United States) is the possibility to engage in bargaining for higher wages (*e.g.*, through trade unions). To opt for this alternative, households must pay a fixed cost of bargaining, which results in self selection of households into the two sectors. In particular, the most productive agents choose to work in the less-competitive sector in exchange for higher wages since they can afford to pay the fixed cost.

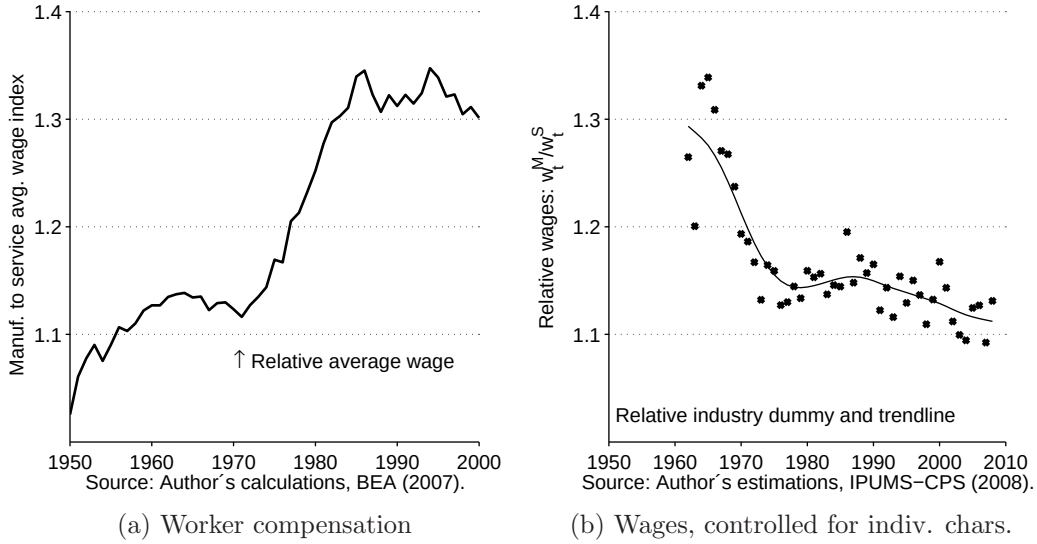


Figure 1.2: Sectoral wages

In addition to the degree of competition in the labor market, sectors in the economy face different degrees of competition in the goods market as well as different rates of productivity growth. The imperfectly competitive goods markets imply that firms earn positive profits, which provide the rents needed for effective wage bargaining. Simultaneously, the manufacturing sector benefits from a higher productivity growth rate than services, consistent with

empirical observations. This implies that manufacturing demand for labor decreases over time, such that the average quality of workers in this less-competitive sector grows. Increasing household productivity results in higher average wages over time. However, as the cost of participating in wage bargaining (*i.e.*, moving to the manufacturing sector) decreases due to the higher household productivity, the average wage per effective unit of labor decreases. Thus, the model can match the increasing average wage and decreasing wages corrected for individual characteristics.

Workers' market power is embodied in trade unions which households may join. Unions in this model should not be taken at face value, since they are simply meant to capture the wage-bargaining power of workers arising from institutional arrangements. I calibrate the model for the United States economy and generate the changes in sectoral employment and wages, as well output share change, productivity growth, and prices consistent with structural change. Moreover, I show this mechanism's quantitative power by fitting a time series on sectoral output and employment for a number of European economies, solely by modifying the parameters associated with labor market power and productivity.

The model's contribution to the literature is that it offers an explanation for employment compensation differentials and proposes a novel approach to structural change. Moreover, it is able to do so without employing capital as a factor of production. To account for changes in output and employment, the existing literature relies one or more of the following elements: different sectoral growth rates, different capital-labor complementarities, and non-homothetic preferences.

For example, among the models employing capital, Kongsamut et al. (2001) use the first two ingredients to induce a decrease in the relative employment of the agricultural sector in favor of the service sector. The change in employment and output shares relies on mapping parameters of the utility function into the production function. In a theoretical paper, Ngai and Pissarides (2007) obtain qualitatively correct changes in output and employment by making assumptions about the elasticity of substitution between manufactured and service goods and the relative rate of technological growth between the two sectors, but no quantitative test on the model is performed. Acemoglu and Guerrieri (2006) use different factor proportions in the production function along with capital deepening to achieve the desired changes in sectoral labor. In this model, the relative output of manufacturing, which has a larger capital share, grows at the time there is a reallocation of capital and labor away from it.

Another stream of the literature incorporates the third element (non-homothetic preferences) into the mix. Papers such as Echevarria (1997; 2000), Stokey (2001), and Buera and Koboski (2006) use non-homothetic preferences to generate different optimal baskets of goods as countries grow. In these models, the income elasticity of goods changes as consumers become richer, generating a changing demand for certain goods. These papers explain the change in output and prices, but not the associated change in employment or wages, which my model does.

More recently, Duarte and Restuccia (2007) use a model with similar preferences to study the connection between structural transformation and productivity growth across countries. In their model, as in Rogerson (2008), labor is reallocated among sectors due to income effects (arising from non-homothetic preferences) and substitution effects (generated by different sectoral productivity growth rates). Non-homotheticities come in the form of subsistence level of agricultural consumption which drives labor out of that sector.² Moreover, these authors employ a similar logic to drive labor *into* the service sector, since they allow for home production of services. A key characteristic these models share with this paper is that labor is the only input of production, although the others do not address changes in wages.

This paper is organized as follows: Section 2 discusses empirical observations on structural change and non-competitive labor markets. In Section 3, I present the model and characterize the equilibrium. I calibrate the model in Section 4. The benchmark calibration is for the United States economy, for which I test the impact of restricting wage bargaining. Then I show that the calibrated model is capable of explaining structural transformation for a number of European economies, characterized by differences in labor market competition. Overall conclusions are presented in Section 5.

2 Structural change and labor markets: empirical evidence

Changes in the relative importance of economic sectors in terms of output and employment were documented as early as the 1950s by Clark (1957) and Kuznets (1957; 1966). The transformation of economies, known as structural change, was a subject of great interest as economists sought to understand the causes of the *industrial revolution*: the transition from

²See Laitner (2000) and Gollin et al. (2002) for other models with this characteristic.

agriculture-based to industry-based economies. Differences in sectoral productivity growth and subsistence level agricultural consumption have been identified as the source of the industrial revolution (see for example, Stokey 2001). Moreover, the process of transformation of the economic structure continues to occur in industrialized nations, which are thought to have mature, almost static economies. In these countries, the primary sector (which includes agriculture and mining) has played a marginal role during the 20th century. Yet, the relative importance of the “industrial” sector is changing; developed nations are becoming overall service economies.

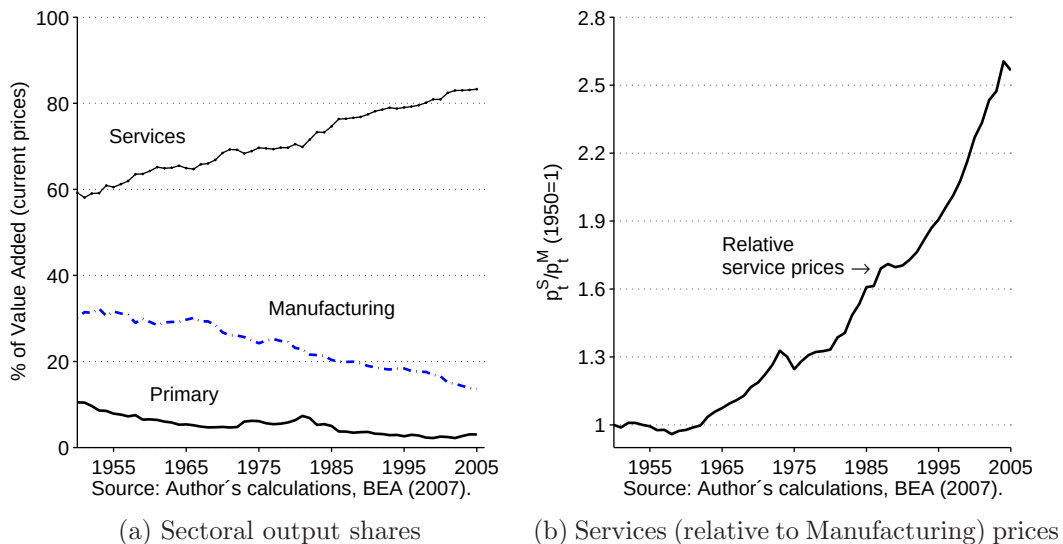


Figure 2.1: Output and prices

In addition to the regularities discussed in the introduction, changes in output composition and prices have been well documented. During the second half of the twentieth century, the share of the service sector in output, measured by value added, increased more than 20 percentage points while that of the manufacturing sector fell, as depicted in Figure 2.1a derived from the U.S. Bureau of Economic Analysis (2007) data. Moreover, output changes were accompanied by shifts in relative prices of the two sectors. During this period, service goods prices, relative to manufacturing, increased more than two-and-a-half times, as shown in Figure 2.1b. This implies that a large portion of the change in output shares is explained by movements in relative prices rather than in real production, as Echevarria (2000) argues.

A model of structural transformation must generate time series consistent with the on

observations on output and prices as well those on wages. As noted in the introduction, average wages in manufacturing, relative to services, grew in the United States between 1950-2000 (Figure 1.2a). In part, sectoral wage differences are explained by differences in worker characteristics, as noted in Katz and Autor (1999) and Heckman et al. (2003). Therefore, I estimate wages equations for the United States between 1962 and 2008 employing CPS data obtained from King et al. (2008).

Following the approach of Angrist and Krueger (1999), I estimate year and industry fixed-effect regressions where the dependent variable is the log-deviation of wages with respect to the economy-wide average of full-time male workers for each year of data available. The availability of individual level data allows me to include control for race (D^b), four age groups (D^a ; 15-24 years, 25-34 years, 35-54 years, 55 years and over), four categories of education (D^e ; less than upper secondary, upper secondary, non-university tertiary, university), region of residence (D^r), and metropolitan area (D^m). Additionally, I include dummies (D^s) indicating the sector where individual j was employed in. Equation (B.1) describes the regression equation for each year t .

$$\begin{aligned} \log w_{j,t} - \log \bar{w}_t &= \tilde{\mathbf{x}}_{j,t} \mathbf{B}_t + \tilde{\gamma}_{j,t} \boldsymbol{\Theta}_t + \eta_{j,t} \\ &= \beta_t^0 + \beta_t^b \tilde{D}_{j,t}^b + \beta_t^m \tilde{D}_{j,t}^m + \sum_{r \in R} \beta_t^r \tilde{D}_{j,t}^r \\ &\quad + \sum_{e \in E} \beta_t^e \tilde{D}_{j,t}^e + \sum_{a \in A} \beta_t^a \tilde{D}_{j,t}^a + \sum_{s \in S} \theta_t^s \tilde{D}_{j,t}^s + \eta_{j,t} \end{aligned} \quad (2.1)$$

where $\tilde{x} \equiv x - \bar{x}$, the individual deviation from the sample mean $\bar{x}$. The vector $\mathbf{x}$ consists of a constant and the individual characteristics dummies, and vector $\hat{\gamma}$ includes the sectoral dummies.

The “true” sectoral wage differential is then approximated from the estimated sector dummy parameters:

$$\frac{\hat{w}_t^M}{\hat{w}_t^S} = e^{\hat{\theta}_t^M - \hat{\theta}_t^S}.$$

The resulting relative wages were depicted in Figure 1.2b and the estimated values are reported in Appendix B.1. It is clear that sectoral differences persist over time, as estimated relative wages differ among sectors. However, there is evidence that relative wages have gone down over the 40-year period analyzed. These observations are consistent with an environment of non-competitive, segmented, labor markets.

Similar international evidence on wage differentials suggests that the presence of non-competitive labor markets is a common occurrence. Jean and Nicoletti (2002) estimate industry markups over the economy-wide average hourly wage for a group of developed countries, correcting for individual characteristics. For most countries, wages are relatively higher in manufacturing than services, as shown in Table B.2.³ Differentials can be attributed to differences in the degree of labor market imperfections between the two sectors.

The model presented next builds on the evidence of segmented labor markets discussed in this section, and provides an explanation for this seemingly contradictory behavior of relative average and per-hour wages. Sector-specific institutional frictions, such as legislation and the presence of unions, result in workers having different market power (see Blanchflower and Bryson 2004). In light of this evidence, I follow Jonsson (2007) and Bayoumi et al. (2004) who use evidence on wage markups and wage differentials between sectors, to calibrate a model with imperfect labor markets.⁴

3 A model of wage bargaining

In light of the facts discussed above, I present a two-sector model which builds on Rogerson (2008) and Duarte and Restuccia (2007) but differs in a number of key aspects. First and most importantly, I assume that labor markets are not perfectly competitive. Firms face trade unions whose objective is to bargain for wages, as in Blanchard and Giavazzi (2003). I allow the degree of bargaining power to differ between industries. As I argued, this is justified by evidence on sectoral wage differences I observed from CPS data for the United States, as well as similar international evidence from Jean and Nicoletti (2002). Firms within a sector share the same technological growth rate and degree of market power, but these characteristics differ across sectors.

There is a unit measure of heterogeneous households whose preferences are represented by a CES utility function over two goods: manufactures and services. Households choose how

³Apart from Italy, France and Belgium also have higher relative service wages.

⁴Monetary, cash-in-advance models like these two can be thought of as reduced versions of the model proposed in this paper. In these models, labor and good markets are assumed to be monopolistically competitive for symmetry and transparency rather than realism. The classical reference in this respect is Blanchard and Kiyotaki (1987). These authors note that because workers have market power, it is more appropriate to think about them as trade-unions rather than individual consumer-workers. Recent references include Bayoumi et al. (2004) and Jonsson (2007).

much to consume of each good and which sector to supply their labor. There is no capital in this model. A full version of the model allows for good and labor market imperfections to occur in both sectors. However, solving such a model reveals that the relative degree of good market competition and labor market power is what matters. Thus, for the sake of simplicity, I assume there is a perfectly competitive sector in both markets and one facing market imperfections.

3.1 Households

Heterogeneous households, which I index by h , derive utility from consuming a composite of differentiated manufacturing goods and a homogeneous service good. Their preferences on consumption are represented by a CES utility function over the two good types.⁵ Additionally, each household supplies its labor endowment inelastically, such that household h 's preferences are represented by:

$$\sum_{t=0}^{\infty} \beta^t \left[\log \left[\gamma (c_t^M(h))^\phi + (1 - \gamma) (c_t^S(h))^\phi \right]^{\frac{1}{\phi}} \right], \quad (3.1)$$

where

$$c_t^M(h) = \left(\int_0^I (c^M(i, h))^\epsilon di \right)^{\frac{1}{\epsilon}}$$

is the composite manufacturing good. Notice this formulation requires the elasticity of substitution between manufactures and services to satisfy $\frac{1}{1-\phi} < 1$ so that the utility function is concave in the two goods. Moreover, the logarithmic form will ensure no intertemporal corner solutions.

Households differ in their productivity level. In particular, each household is endowed with h indivisible units of effective labor. I assume h comes from a Pareto distribution in the interval $[1, \infty)$.⁶ The CDF and PDF for this distribution are then:

$$F(h) = 1 - h^{-b}, \quad f(h) = bh^{-b-1}.$$

⁵Cobb-Douglas utilities will yield the undesired result that nominal relative consumption between sectors will be constant, with physical quantities varying according to productivity differentials. See Echevarria (1997) for more on this issue.

⁶Empirical work shows wealth and income have distributions which are positively skewed, with a top tail approximated by a Pareto distribution, as reported by Davies and Shorrocks (2000).

In any period, a household can only supply labor to one sector. Its sequential budget constraint is then:

$$\int_0^I p_t^M(i) c_t^M(i, h) di + p_t^S c_t^S(h) \leq Y_t(h) + \pi_t$$

where $Y_t(h)$ is the labor income household h earns and π_t is its share of aggregate profits in the manufacturing sector. The claims over profits are the same across households. Below, I briefly discuss households' choice of sector in which to work.

A household which chooses to work in the service sector will receive a wage w_t^S equal to the marginal product of one unit of effective labor. Alternatively, households may choose to enter a wage-bargaining process in the manufacturing sector. To this effect, they must incur a cost κ , which is common across households. Those who pay this cost, form a union which in turn bargains with firms in a right-to-manage fashion: unions bargain for wages, but firms retain the power to hire and fire workers. The income of households employed in manufacturing, net of bargaining fee, is $w_t^M h - \kappa$, where w_t^M is the wage that arises from the bargaining process.⁷

In summary, household h 's problem is:

$$\begin{aligned} & \max_{\{c_t^M(h), c_t^S(h), J_t(h)\}} \sum_{t=0}^{\infty} \beta^t \left[\log \left[\gamma (c_t^M(h))^{\phi} + (1 - \gamma) (c_t^S(h))^{\phi} \right]^{\frac{1}{\phi}} \right] \\ & \text{s.t.} \end{aligned} \tag{3.2}$$

$$\int_0^I p_t^M(i) c_t^M(i, h) di + p_t^S c_t^S(h) \leq J_t(h) w_t^S h + (1 - J_t(h)) (w_t^M h - \kappa) + \pi_t$$

$$c_t^M(h) = \left(\int_0^I (c_t^M(i, h))^{\epsilon} di \right)^{\frac{1}{\epsilon}}.$$

where $J_t(h)$ is an indicator function that takes the value one if the household chooses to work for the service sector and zero if it chooses to bargain for wages in the manufacturing sector.

Solving the problem above yields the optimal basket of consumption $\{c_t^M(h), c_t^S(h)\}$ given the household's income. This is needed to solve the bargaining problem, which I discuss in detail in Section 3.4.

⁷For a detailed treatment of the wage bargaining process, see Section 3.4.

3.2 Service sector

The service sector produces a homogeneous good and faces a competitive labor market. I assume this sector has a constant-returns-to-scale production technology which only uses labor as input. Under these assumptions, the representative firm in the sector has technology:

$$C_t^S \leq A_t^S L_t^S, \quad (3.3)$$

where A_t^S is the industry-wide productivity parameter and L_t^S is total labor employed:

$$L_t^S = \int_{h \in \mathcal{H}_t^S} h dF(h),$$

where $\mathcal{H}_t^S$ is the set of workers employed in the service sector in period t . The labor requirement is an aggregation of individuals' efficient units of labor. Hence, there is a disconnect between labor demand and employment which is key to the model, as I discuss later.

The industry-wide productivity parameter evolves over time, reflecting changes in labor productivity. Finally, output is sold as a consumption good to households. Hence, the problem of the representative service firm is:

$$\max_{\{L_t^S\}} \left\{ p_t^S A_t^S L_t^S - w_t^S L_t^S \right\} \quad (3.4)$$

The constant returns to scale feature allows the sector to accommodate all households that choose to work there in exchange for the competitive wage.

3.3 Manufacturing sector

The manufacturing sector faces non-competitive output and labor markets. This sector is composed of a fixed measure I of firms, each producing a differentiated good $c^M(i)$. Firms compete monopolistically, generating profits which are at the core of wage bargaining as households try to capture them by bidding for higher wages.

The continuum of firms assumption allows me to ensure that no firm will be big enough to affect aggregate variables. Firm i 's optimal decision comes from solving the following

problem taking wage as given:

$$\begin{aligned}
& \max_{p_t^M(i), l_t^M(i)} \{p_t^M(i)c^M(p_t^M(i), P_t^M) - w_t^M(i)l_t^M(i)\} \\
& \text{s.t.} \\
& c^M(p_t^M(i), P_t^M) \leq A_t^M l_t^M(i)
\end{aligned} \tag{3.5}$$

where

$$c^M(p_t^M(i), P_t^M) = \int_0^{N_t} c^M(p_t^M(i), P_t^M; h)dh$$

is the aggregate demand for good i and $c^M(p_t^M(i), P_t^M; h)$ is household h 's demand for good i at time t ; A_t^M is the sector-wide productivity level, $w_t^M(i)$ is the wage paid by firm i (which arises from the wage bargaining problem), and $l_t^M(i)$ is the firm's labor demand.

Given the optimal demand for labor arising from solving the problem above, firms negotiate for wages with the trade union, as I describe in the next section.

3.4 Wage bargaining

In this section I describe the wage bargaining process that takes place in this economy and the parties involved in it. A generalized treatment of the topic can be found in Layard et al. (2005).

Who bargains? On the employers side, all firms in the manufacturing sector participate in wage bargaining. This is not the case for households, however.

For each period, a household's choice between joining a union to bargain for wages in the manufacturing sector and remaining employed at the competitive wage in the service sector depends on its cost of bargaining κ and ability h . Households choose to unionize if the income resulting from wage bargaining exceeds that of working in the service sector. This condition is formalized in Proposition 1.

Proposition 1 *Households will choose to join a wage-bargaining union in the manufacturing sector if and only if the following condition is satisfied:*

$$w_t^M h - \kappa \geq w_t^S h. \tag{3.6}$$

that is, the net labor income of bargaining wages exceeds the service sector wage.

Proof First, I solve the consumer's problem (3.2), given income $Y_t(h)$, to obtain the optimal basket of consumption:

$$\{c_t^M(h), c_t^S(h)\} = \frac{Y_t(h)}{(1 - \gamma)^{\frac{1}{\phi-1}} P_t^{M \frac{\phi}{\phi-1}} + \gamma^{\frac{1}{\phi-1}} p_t^{S \frac{\phi}{\phi-1}}} \left\{ (1 - \gamma)^{\frac{1}{\phi-1}} P_t^{M \frac{1}{\phi-1}}, \gamma^{\frac{1}{\phi-1}} p_t^{S \frac{1}{\phi-1}} \right\}, \quad (3.7)$$

where P_t^M is the price of the manufacturing composite. I plug (3.7) into the utility function to obtain the indirect utility function $V(Y_t(h), p_t^S, P_t^M)$, which depends on income and prices only.

Since in a CES utility function

$$w \geq w' \Rightarrow V(w; \cdot) \geq V(w'; \cdot)$$

for given prices, (3.6) implies that $V(w_t^M h - \kappa; \cdot) \geq V(w_t^S h; \cdot)$. Workers choose to bargain if expected income of such a process exceeds the competitive wage.

The opposite direction of the proposition comes from $V(w; \cdot) \geq V(w'; \cdot) \Rightarrow w \geq w'$. ■

Notice that for the case where $w_t^M h - \kappa = w_t^S h$, household h will be indifferent between working in services or manufacturing, given prices and wages. Therefore, there exists a level $h_t^*(W_t^M)$, which depends on aggregate wages, such that households with $h \geq h_t^*(W_t^M)$ will choose to embark in wage bargaining (see Figure 3.1).

What do the parties seek to obtain? Union members vote for wages in order to maximize the value of being employed in the manufacturing sector, relative to the alternative of working in the competitive sector. The value of a “move” from services to manufacturing for a household type h can be written as:

$$w^M h - \kappa - w^S h,$$

if it is employed in M , or

$$-\kappa,$$

if it does not get a job there and must return to S (such that there is no gain in wage, but a cost of engaging in wage bargaining of κ). The alternative is not to engage in wage

bargaining at all, such that the gain from a move is zero. Therefore, the union's objective is:

$$\theta(w^M h - \kappa - w^S h) + (1 - \theta)(-\kappa),$$

where the probability of being employed in manufacturing, $\theta \equiv \min\left(1, \frac{N}{\tilde{N}}\right)$, depends on the number of workers employed N and the number of households who join the union $\tilde{N}$.

Since there is no uncertainty in the model, the number of workers who join the union will be equal to the number who will get a job, such that $\theta = 1$. Moreover, the union cares about the outcome of all of its members (*i.e.*, it takes its members' employment into account):

$$\int_{h \in \mathcal{H}^M(i)} (h[w^M - w^S] - \kappa) dF(h) = N_t^M(i) \bar{h}^M(\cdot) [w^M - w^S] - N_t^M(i) \kappa,$$

where $\mathcal{H}_t^M(i)$ is the set of households who join union i , $N_t^M(i)$ is the number of workers in this set, and $\bar{h}(h^*(W^M)) \equiv E(h|h \geq h^*(W^M)) = \frac{b}{b-1} h^*(W^M)$, the average productivity of workers who engage in wage bargaining. The average efficiency units of labor for a worker in manufacturing is defined by a cutoff level of efficiency units of labor. This cutoff, which comes from (3.6), indicates that workers whose innate productivity exceeds $h^*(W^M)$ will join manufacturing, while the rest remain in services. This result is depicted in Figure 3.1.

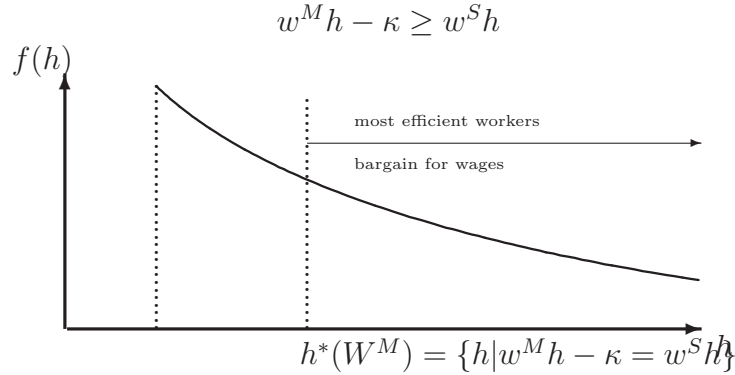


Figure 3.1: Worker productivity cutoff

Using the equilibrium condition that a firm's labor requirement must equal effective labor supplied by the union:

$$l^M(i) = N^M(i) \bar{h}^M(\cdot),$$

I write the union's value of wage bargaining as:

$$l^M(i) \left[w^M(i) - w^S - \frac{\kappa}{\bar{h}^M(\cdot)} \right].$$

On the other hand, a firm seeks to maximize profits, compared to the alternative of not reaching an agreement and shutting down. Profit as a function of the bargained wage comes from solving firm i 's problem (3.5). After obtaining labor demand, I plug it back into the profit function to obtain:

$$\pi(w^M(i)) = w^M(i) l^M(w^M(i)) \frac{1 - \epsilon}{\epsilon}.$$

Since the firm's alternative is to generate zero profits, the above expression is the firm's objective function. I require all firms in manufacturing to negotiate with an equivalent fraction of the households who choose to engage in bargaining.⁸ This assumption, along with the fact that manufacturing firms have the same technology, will ensure symmetry among firms in this sector.

The two parties' objectives are brought together into a Nash bargaining objective function:

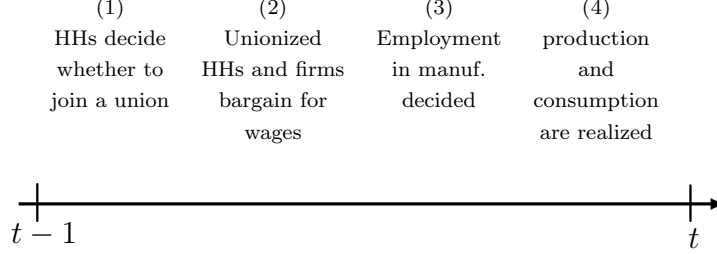
$$\Omega(w^M(i)) = \rho \log \left(\left[w^M(i) - w^S - \frac{\kappa}{\bar{h}^M(\cdot)} \right] l^M(w^M(i)) \right) + (1 - \rho) \log (\pi(w^M(i))), \quad (3.8)$$

where ρ is the union's bargaining power, which I assume identical across all union-firm pairs. Notice that since I assumed the firm and union are very small, their decisions do not affect h^* (through $\bar{h}^M(\cdot)$), the cutoff level of labor productivity, or any other aggregate variable.

A summary of the timing of wage bargaining is described next:

⁸Due to the CES aggregation of manufacturing goods, this fraction will be $I^{\frac{1}{\epsilon}}$, as I show in the equilibrium characterization.

Timing:



3.5 Market clearing conditions

Given a measure one of households, all goods and input markets must clear in every period:

$$\begin{aligned}
 C_t^S &= \int_0^1 c_t^S(h) dh; & L_t^S &= \int_1^{h_t^*} h dF(h); \\
 c_t^M(i) &= \int_0^1 c_t^M(i, h) dh, \forall i \in \{0, I\}; & L_t^M &= \int_{h_t^*}^\infty h dF(h); \\
 C_t^M &= \int_0^1 c_t^M(h) dh; & N_t^M + N_t^S &= 1.
 \end{aligned}$$

The last condition comes from the assumption that no unemployment exists in the economy.

3.6 Equilibrium characterization

Equilibrium consists of quantities $\{\{c_t^M(i, h)\}_{i=0}^I, c_t^S(h)\}$ and a cutoff h_t^* that solve the households' (3.2) and firms' (3.4 and 3.5) problems, given the households' bargaining cost κ , choice of work $\{J_t(h)\}$, prices, and wages. Manufacturing sector wages come from solving the bargaining problem (3.8), which in turn determines the household's choice of work and employment in each sector.

In light of Proposition 1, I solve the household's problem to obtain the optimal basket of manufacturing composite and service consumption goods $\{c_t^M(h), c_t^S(h)\}$. Notice that these quantities depend on income and, therefore, on the job choice of households. From the household's problem, I also obtain the demand function for manufacturing good i :

$$c_t^M(i, h; p_t^M) = \frac{p_t^M(i)^{\frac{1}{\epsilon-1}}}{P_t^{M \frac{1}{\epsilon-1}}} c_t^M(h; P_t^M), \quad (3.9)$$

where $P_t^M = \left(\int_0^I p_t^M(i)^{\frac{\epsilon}{\epsilon-1}} di \right)^{\frac{\epsilon-1}{\epsilon}}$. Plugging equation (3.9) into the manufacturing firm's profit maximization problem, yields the price for good i :

$$p_t^M(i) = \left[\frac{1}{\epsilon} \frac{w_t^M(i)}{A_t^M} \right] \quad (3.10)$$

which is a markup over the effective wage paid by firm i . This expression then allows me to write the firm's labor requirement and profit functions as:

$$l_t^M(w_t^M(i)) = \left[\frac{w_t^M(i)^{\frac{1}{\epsilon-1}}}{A_t^M} \right] \frac{C_t^M}{(\epsilon P_t^M)^{\frac{1}{\epsilon-1}}}, \quad (3.11)$$

$$\pi_t(w_t^M(i)) = \left[\frac{w_t^M(i)}{A_t^M} \right]^{\frac{\epsilon}{\epsilon-1}} \frac{C_t^M}{(\epsilon P_t^M)^{\frac{1}{\epsilon-1}}} \frac{1-\epsilon}{\epsilon}. \quad (3.12)$$

Next, I solve the bargaining problem (3.8) to obtain the wage. The first order condition can be manipulated to obtain:

$$w^M(h_t^*) = \left[1 + \underbrace{\left(\rho \right)}_{(1)} \underbrace{\left(\frac{1}{\epsilon} - 1 \right)}_{(2)} \right] \left[w_t^S + \underbrace{\frac{\kappa}{\bar{h}^M(h_t^*)}}_{(3)} \right]. \quad (3.13)$$

Equation (3.13) has three important implications. First, all manufacturing firms and household union pairs will agree on the same wage. This arises from the fact that all union-firm pairs are symmetric. Second, this unique manufacturing wage exceeds the competitive wage (the one paid in the service sector). Finally, the wage depends on (1) the bargaining power of worker-unions, (2) manufacturing firms' market power, and (3) the effective cost of bargaining. This last term will change over time as labor is reallocated between the two sectors, changing the wage paid in manufacturing.

Next I derive sectoral consumption, labor requirement, and employment. First, I integrate (3.9) over consumers' h . Since all firms charge the same price p_t^M for their good and, thus, behave symmetrically ($c_t^M(i) = c_t^M, \forall i$), I manipulate (3.9) to obtain:

$$C_t^M = I^{\frac{1}{\epsilon}} c_t^M.$$

With the condition above, sectoral output in equilibrium is:

$$C_t^S = A_t^S L_t^S, \quad (3.14)$$

$$C_t^M = I_t^{\frac{1}{\epsilon}} c_t^M = A_t^M (I_t^{\frac{1}{\epsilon}} l_t^M), \quad (3.15)$$

where the last equality used the firm's production function. Let $L_t^M \equiv I_t^{\frac{1}{\epsilon}} l_t^M$ be the manufacturing sector's total labor requirement. Integrating the consumers' relative consumption equation over h yields the aggregate relative consumption:

$$\begin{aligned} \frac{C_t^S}{C_t^M} &= \left[\frac{\gamma}{(1-\gamma)} \frac{p_t^S}{P_t^M} \right]^{\frac{1}{\phi-1}} \\ \Rightarrow \frac{L_t^S}{L_t^M} &= \left[\frac{\gamma}{(1-\gamma)} \frac{w_t^S}{w^M(h_t^*)} \frac{\epsilon}{I_t^{\frac{\epsilon-1}{\epsilon}}} \right]^{\frac{1}{\phi-1}} \left[\frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}} \end{aligned} \quad (3.16)$$

where last line used (3.14), (3.15), (3.10), and $p_t^S = \frac{w_t^S}{A_t^S}$. To obtain labor allocation between sectors, I must transform the labor requirement in equation (3.16) into an expression containing the cutoff level of labor productivity h_t^* . To do so, recall that in equilibrium the labor requirement in each sector must satisfy:

$$\begin{aligned} L_t^S &= \int_1^{h_t^*} h dF(h) = N_t^S \bar{h}^S(h_t^*), \\ L_t^M &= \int_{h_t^*}^{\infty} h dF(h) = N_t^M \bar{h}^M(h_t^*). \end{aligned}$$

Substituting these two expressions into (3.16), some manipulation yields:

$$\frac{N_t^S \bar{h}^S(h_t^*)}{N_t^M \bar{h}^M(h_t^*)} = \frac{(h_t^*)^b - h_t^*}{h_t^*} = \left[\frac{\gamma}{(1-\gamma)} \frac{w_t^S}{w^M(h_t^*)} \frac{\epsilon}{I_t^{\frac{\epsilon-1}{\epsilon}}} \right]^{\frac{1}{\phi-1}} \left[\frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}}, \quad (3.17)$$

where I used the Pareto distribution for worker abilities. Equation (3.17) implicitly gives the solution for h_t^* and, thus, the fraction of the population working in each sector at time t .

Following the same logic used to derive (3.16), I obtain the ratio of current price consumption:

$$\frac{p_t^S C_t^S}{P_t^M C_t^M} = \left[\frac{\gamma}{(1-\gamma)} \right]^{\frac{1}{\phi-1}} \left[\frac{w_t^S}{w^M(h_t^*)} \frac{\epsilon}{I_t^{\frac{\epsilon-1}{\epsilon}}} \frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}}. \quad (3.18)$$

Conditions (3.13), (3.17), and (3.18), together with:

$$\frac{p_t^S}{P_t^M} = \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \frac{w_t^S}{w^M(h_t^*)} \frac{A_t^M}{A_t^S}, \quad (3.19)$$

complete the equilibrium characterization.

4 Calibration

In this section I show how the model presented in Section 3 can generate the time series on employment, output, and wages observed in a number developed economies. My benchmark calibration is for the United States for the 1950-2000 period. Then, to illustrate the importance of wage bargaining, I calibrate a version of the model where no wage bargaining is allowed. I show that this version fails to generate all the features of structural change, even when a counterfactual elasticity of substitution between sectors' goods is imposed. Finally, I evaluate the model's performance regarding employment and output for a number of European economies between 1970 and 2000.

4.1 Wage bargaining in the U.S.: 1950-2000

In this subsection, I calibrate the model for the 1950-2000 period in the United States. Table 4.1 summarizes the key parameters for this calibration. I calculate the relative wages for 1962-2000 using CPS data following the approach used by Angrist and Krueger (1999). Details on the estimations appear in companion paper Ricaurte (2009). I choose to match the year 2000 estimate, since my calibration sets parameters according to the end points of the selected period:⁹

$$\frac{w_{2000}^M}{w_{2000}^S} = 1.148.$$

The initial levels of output per worker were set to one and the productivity parameters adjusted by the sectoral average worker productivity, as described in Appendix C. Finally, notice that the elasticity of substitution parameter for consumption arising from the selected

⁹Calculated the relative wages from Jean and Nicoletti (2002) for 1998 are 1.107. For more details, see Appendix B.2.

Table 4.1: Calibration 1

Parameter	Value	Description	Target
γ	0.488	manufactured goods weight	$\frac{N^S}{N^M}, 1950$
$\frac{1}{1-\phi}$	0.364	elast. subs. M, S	$\frac{N^S}{N^M}, 2000$
I	7086	measure of manuf. firms	$\frac{p^S C^S}{P^M C^M}, 1950$
b	2.1	Pareto distrib. shape param.	distribution of wages*
κ	0.362	bargaining cost	N_{2000}^M
ρ	0.437	union bargaining power	$\frac{w_{2000}^M}{w_{2000}^S}$
ϵ	0.870	inv. manuf. price markup	Bayoumi et al. (2004)
g_{A^M}	(*)	manuf. output per worker growth	BEA
g_{A^S}	(*)	serv. output per worker growth	BEA

(*): For construction details, see Data Description in Appendix C.
 (*): Measured by Gini coefficient of 0.33, see discussion.

ϕ is 0.364. This value is in the 95% confidence interval arising from the co-movement between quantities and prices of the two goods:¹⁰

$$\frac{1}{1-\phi} \approx \text{corr} \left(\log \left(\frac{C_t^M}{C_t^S} \right), \log \left(\frac{P_t^M}{p_t^S} \right) \right) \in (0.338, 0.730).$$

In the context of other models with similar preferences, Rogerson (2008) calibrates the parameter to be -1.28 and Duarte and Restuccia (2007) to -1.5.

I am interested in obtaining the employment (3.17) and nominal consumption (3.18) ratios, the change in relative prices (3.19) and wages (3.13), and the growth of constant-price sectoral output (consumption).

I calibrate the model to match employment, which is depicted in Figure 4.1. Current price output shares are closely matched, as appears in Figure 4.2. Output per worker trends' (*i.e.*, HP-filter) growth rates for each sector are shown in Figures 4.3. The trend's annualized growth rate for the period is 3.1% for manufacturing, and 1.0% for services. The model predicts growth rates of 3.7% and 1.0%, respectively. It also implies that faster growth in the manufacturing sector comes not only from the overall technological improvement, but also from improvements on the average ability of households in the sector. The latter occurs

¹⁰This value is calculated with output and price ratios for the 1952-2000 range, excluding five years on each end of the range for statistical purposes.

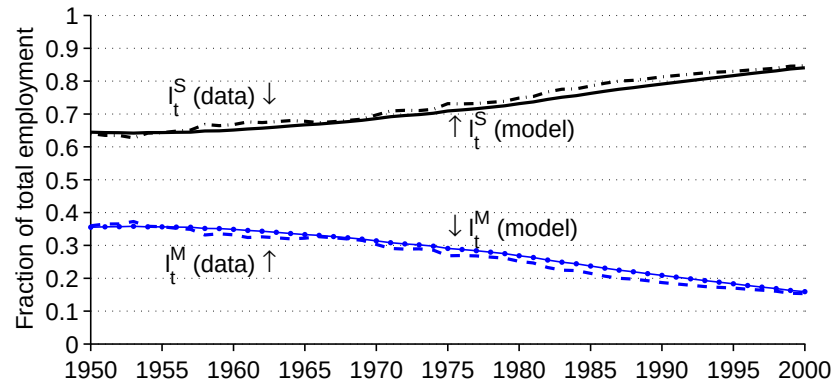


Figure 4.1: Sectoral shares of employment

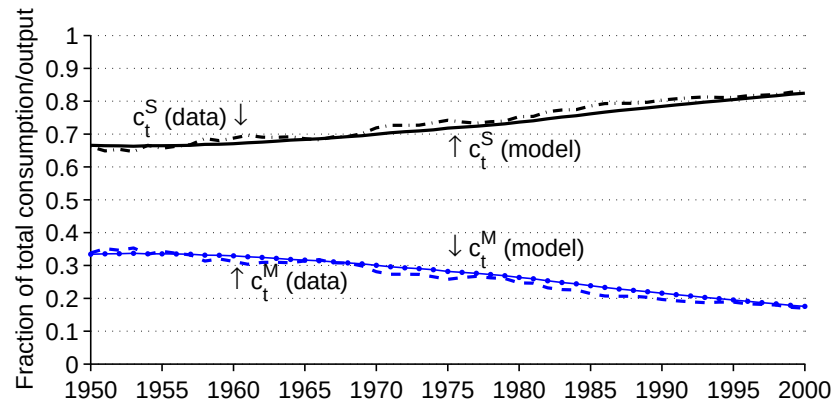


Figure 4.2: Sectoral shares of output, current prices

because over time, the fraction of workers who switch to manufacturing decreases, meaning ever more productive households are employed in this sector.

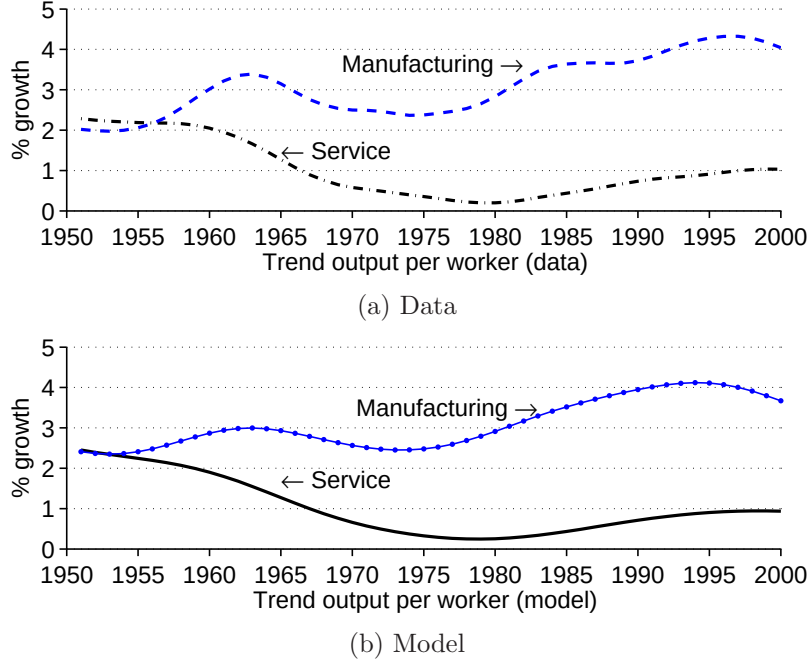


Figure 4.3: Sectoral output growth rate, constant prices

Relative sectoral wages decrease over time (see Figure 4.4). This trend is captured in equation (3.13). As fewer workers are employed in manufacturing, only the most efficient choose to switch to this sector. Raising average worker productivity, in turn, decreases the cost of bargaining per effective unit of labor, h . Hence, the wage arising from the bargaining process decreases, as workers are compensated for a lower effective cost of bargaining, $\frac{\kappa}{h^M(\cdot)}$. Moreover, the model also generates the increasing relative average wages observed in the data (see Figure 4.5), allowing for these two phenomena to occur simultaneously. As relative wages per efficient unit of labor decrease over time, the human capital endowment for the average worker in manufacturing increases. In fact, the latter increase surpasses the drop in wages, resulting in the observed increase in average (*i.e.*, per capita) wages.

The decrease in relative manufacturing wages and faster growth in manufacturing productivity are consistent with a change in relative prices larger than that observed in the data. Figure 4.6 shows the model predicts an increase of relative service prices during the period of 190% compared to 120%, obtained from BEA data.

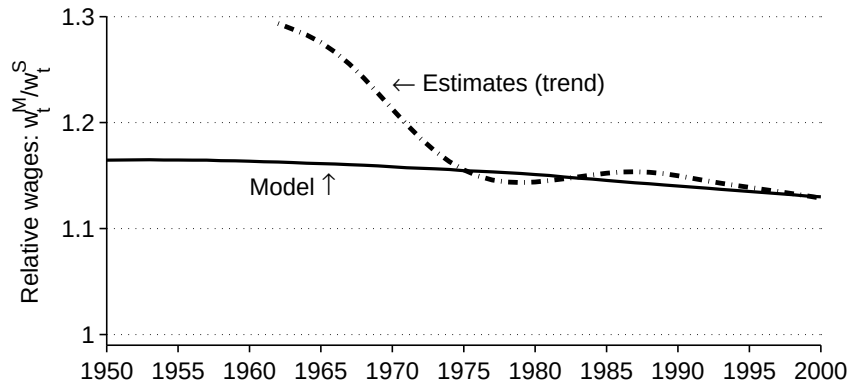


Figure 4.4: Manufacturing over service sector wages

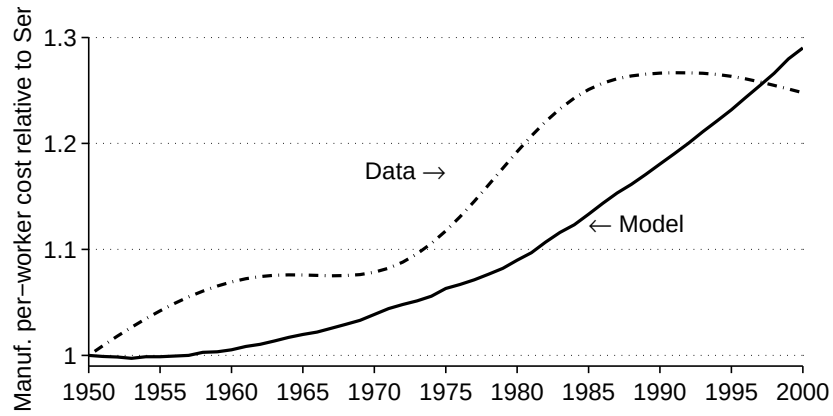


Figure 4.5: Relative average wages (manuf./serv.)

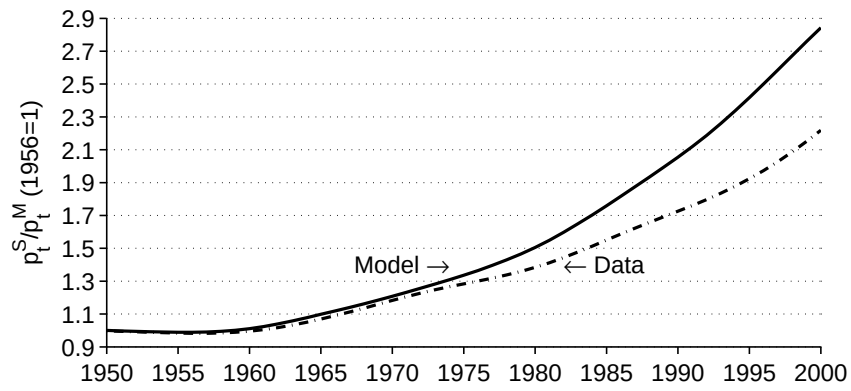


Figure 4.6: Relative prices

4.2 No wage bargaining, U.S.: 1950-2000

Next, I solve a version of the model where no wage bargaining is allowed. The immediate result of this assumption is that the model will fail to generate differences in the wage per efficient unit of labor and its evolution over time. Additionally, the model will fail to generate other regularities associated with structural change, as I argue below.

Since both sectors pay the same wage w_t per unit of effective labor, households are indifferent between working in either sector of the economy. Their utility maximization problem will remain unchanged, except that they do not actively choose the sector they want to work in. As before, firms are indifferent to which workers they hire, as long as their labor requirement is satisfied. Therefore, employment cannot be pinned down and I cannot draw a comparison between this variation of the model and the full model in this dimension.¹¹

Hence, the equilibrium consists of quantities $\{c_t^M(h), c_t^S(h)\}$ as in (3.7), where income $Y_t(h) = w_t h + \pi$, and $c_t^M(h) = \left(\int_0^I c_t^M(i, h)^\epsilon di \right)^{\frac{1}{\epsilon}}$; and labor requirement given by (3.11) for manufacturing firms and by the technological requirement for services, given prices:

$$\{p_t^M(i), p_t^S\} = \left\{ \frac{w_t}{\epsilon A_t^M}, \frac{w_t}{A_t^S} \right\};$$

which arise from the profit maximization problem of the firms. As before, all manufacturing firms will charge the same price for their differentiated good. Conditions (3.14) and (3.15) remain unchanged, while (3.17), (3.18), and (3.19) are replaced by:

$$\frac{L_t^S}{L_t^M} = \left[\frac{\gamma}{(1-\gamma)} \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \right]^{\frac{1}{\phi-1}} \left[\frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}}, \quad (3.17')$$

$$\frac{p_t^S C_t^S}{P_t^M C_t^M} = \left[\frac{\gamma}{(1-\gamma)} \right]^{\frac{1}{\phi-1}} \left[\frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}}, \quad (3.18')$$

$$\frac{p_t^S}{P_t^M} = \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \frac{A_t^M}{A_t^S}, \quad (3.19')$$

respectively.

Table 4.2 shows the key parameters for this calibration. Notice that I use the same weight

¹¹Moreover, I cannot make a statement regarding which sector has higher average worker productivity, unlike the wage-bargaining case.

of manufacturing consumption in the utility function and distribution of abilities from my benchmark calibration. I then calibrate A_{1956}^M and I to match 1950 ratios of employment and relative sectoral output.

Table 4.2: Calibration 2

Parameter	Value	Description	Target
b	2.0	Pareto distrib. shape param.	Table 4.1
γ	0.821	manufactured goods weight	initial $\frac{L^S}{L^M}$
I	4.792	measure of manuf. firms	initial $\frac{p^S C^S}{\frac{P^M C^M}{\frac{N^S}{N^M}}}$

The key parameter to calibrate in this experiment is the elasticity of substitution between manufacturing and services. With a value statistically close to the data, output shares 2000 are not matched by the model, as show in the second row of Table 4.3. Thus, I reset ϕ to improve the calibration. In order to match output shares reasonably well, I need to set $\phi < -10$. Predicted prices do not improve significantly either. The drawback with this calibration is that it requires the elasticity of substitution between manufactures and services which is outside the confidence interval estimated from the data (see Section 4.1). The last row in Table 4.3 shows these results.

Table 4.3: Elasticity of substitution, output and prices in 2000

	$\frac{p^S C^S}{GDP}$	$\frac{p^M C^M}{GDP}$	$\frac{P^M \star}{p^S}$	$\frac{1}{1-\phi}$
Data $\longrightarrow$	0.83	0.17	0.44	$(0.338, 0.730)^\dagger$
Calibration $\downarrow$				
$\phi = -1.7$	0.79	0.21	0.36	0.364
$\phi = -10.0$	0.82	0.18	0.36	0.091

($\star$): Relative to 1950 prices.
($\dagger$): 95% confidence interval.

4.3 Wage bargaining in Europe

In this section, I show the model’s predictive performance for eight European economies: Austria, Belgium, France, Denmark, Italy, Spain, Sweden, and the United Kingdom.¹² Due to data limitations, I had to recalibrate the model used in Section 4.1. In particular, since I use OECD (OECD Statistics Directorate (2007a;b)) data for employment and output, the analysis is restricted to the 1970-2000 period. Also, these data are organized in sectors differently than BEA data for the United States (Table A.1 shows the sectoral composition used in calibration, compared to that in Sections 4.1 and 4.2). Table 4.4 shows the parameters in the model calibration for the United States. Notice that the elasticity of substitution parameter used to calibrate the model differs with that selected in Section 4.1, but is consistent with the implied 95% confidence interval for the elasticity of substitution between manufactures and services for the period: (0.097,0.685).

Table 4.4: Calibration 3

Parameter	Value	Description	Target
γ	0.700	manufactured goods weight	$\frac{N^S}{N^M}$, 1970
$\frac{1}{1-\phi}$	0.191	elast. subs. M, S	$\frac{N^S}{N^M}$, 2000
I	4526	measure of manuf. firms	$\frac{p^S C^S}{P^M C^M} \frac{N^S}{N^M}$, 1970
b	2.1	Pareto distrib. shape param.	distribution of wages*
κ	0.328	bargaining cost	N_{1998}^M
ρ	0.488	union bargaining power	$\frac{w_{1998}^M}{w_{1998}^S}$
ϵ	0.870	inv. manuf. price markup	Bayoumi et al. (2004)
g_{AM}	(*)	manuf. output per worker growth	BEA
g_{AS}	(*)	serv. output per worker growth	BEA

(*): For construction details, see Data Description in Appendix C. (*): Measured by Gini coefficient of 0.33, see discussion.

Given the calibrated parameters for the utility function, I follow Rogerson (2008) to account for the eight European countries in 1970. In particular, I adjust the relative productivity in this year to match the employment shares, recalibrate I to match the 1970 $\left(\frac{p^S C^S}{P^M C^M}\right) / \left(\frac{N^S}{N^M}\right)$ ratio, and κ and ρ according to the countries’ wage differentials reported

¹²The sample of countries was selected due to data availability for sectoral wages, output, and employment. See Appendix A for details.

in Table B.2. Figure 4.7 compares data on shares of output and employment in services in 2000 to the model's predictions. The closer the model points are to the 45-degree line, the better the prediction. It is obvious that the model does a good job of matching structural change after 30 years for the eight European economies.

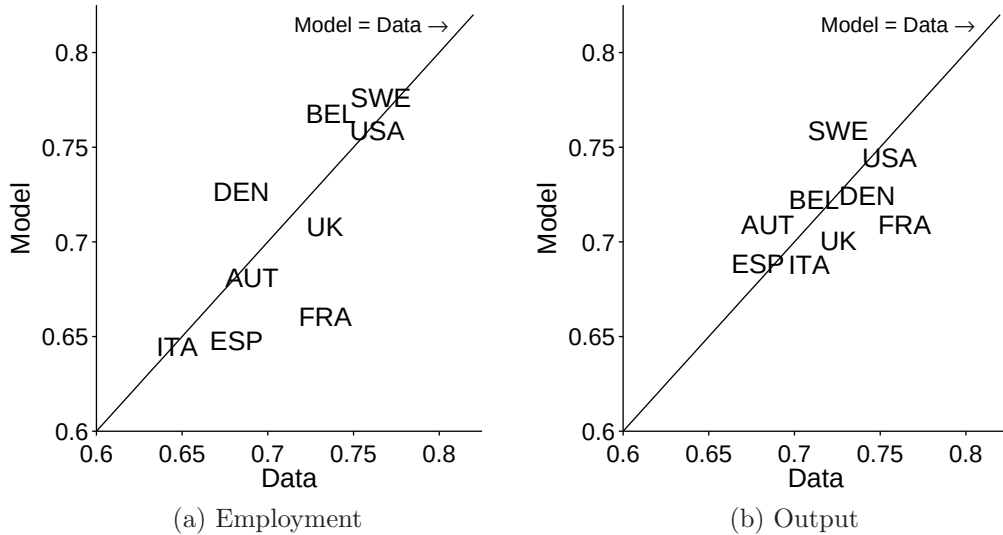


Figure 4.7: Wage bargaining case: employment and output

If wage bargaining is not allowed, the model cannot predict employment shares and does a poor job predicting output shares. I employ an estimation strategy analogous the one used in the no-wage bargaining case for the United States (see Section 4.2). I present results for two cases. The first case employs the same elasticity of substitution (0.191) used to calibrate the model for the United States when wage bargaining is an option.¹³ These results are depicted in Figure 4.8a. In the second case, I set the elasticity of substitution to 0.091 in order to improve the prediction for the United States. It can be seen in Figure 4.8b that even with this extremely low elasticity of substitution, the model fails to accurately predict the output share of services in the United States in the year 2000. Notice that this value for the elasticity of substitution is outside the 95% confidence interval for the 1970-2000 period. Moreover, with the exception of Denmark, the model underestimates the share of services in total output in the year 2000. This result points at the contribution of wage bargaining to the process of structural change.

¹³Other parameters in the calibration remain unchanged.

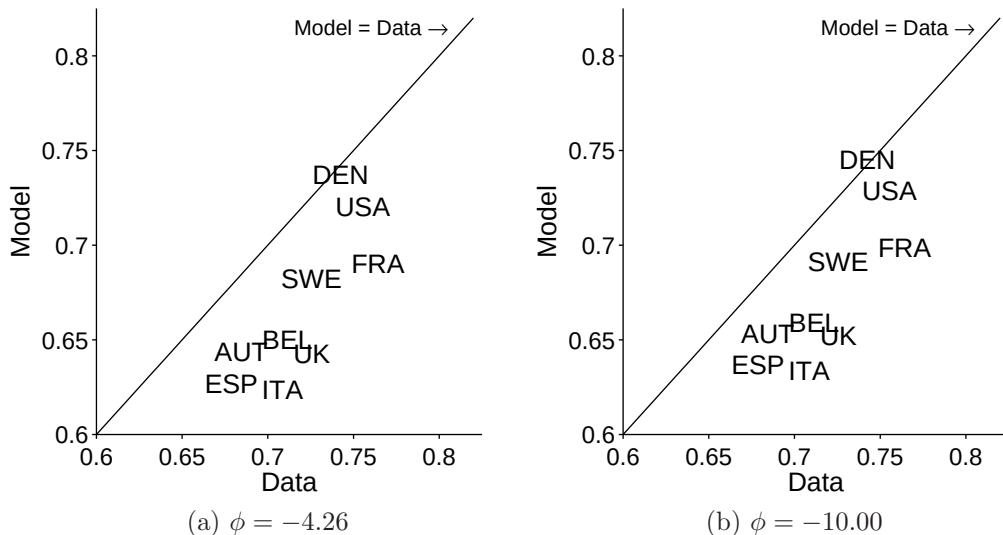


Figure 4.8: No bargaining case: output

5 Conclusions

In an attempt to understand why services become the dominant sector in industrialized economies, I have proposed a model of labor market imperfections that successfully generates the aggregate patterns in sectoral output, employment, and wages observed in the data for the United States, and accommodates the different experiences of a number of European economies during the last decades of the twentieth century. This paper not only contributes by adding to the understanding of the mechanics behind the second wave of structural transformation, but also closes the gap between the macroeconomic aspects of structural change, and the microeconomic evidence on labor market performance. In particular, the model generates a micro-founded explanation for rising average labor payments in manufacturing, and falling in wages after controlling for individual characteristics.

To do this, I developed and calibrated a two-sector model where households bargain with firms for wages. This process is at the heart of the labor (and production) dynamics of the economy. As workers face the tradeoff between staying in the competitive sector of the economy, and paying the cost of bargaining for higher wages, self-selection between the sectors will occur in the benchmark model. The most productive households will choose to engage in wage bargaining (*i.e.*, switch to manufacturing), while the least productive ones stay in services. Firms in both sectors care about the labor input requirement and not the

number of workers they employ. Hence, low efficiency households stay in the service sector, driving up the number of workers employed in this sector. This fact is important as the majority of models studying structural change are not suited to account for changes in both output and employment shares of the economy.

A remarkable feature of the model is that the relative degree of imperfections in the goods and labor markets is what matters. Hence, even when the model laid out in this paper assumes services to be perfectly competitive, results will be equivalent if both sectors face market imperfections, with less competitive markets in manufacturing in the case of the United States. This also implies that the model can easily be reinterpreted for cases where the least competitive market is services, as is the case of France, Denmark, and Italy.

A limitation of the version of the model discussed here is the overly simplistic labor market it faces. In particular, the model implies that the most efficient households in the economy will be employed in the manufacturing sector and will choose to unionize. In reality, the level of human capital, measured by educational attainment, of workers in manufacturing is not the highest, but rather “average,” as documented in Lee and Wolpin (2006). An extension of the model, currently in progress, seeks to replicate this empirical observation. Never-the-less, the fact that all households employed in manufacturing are unionized should not be taken at face value. The idea behind this result is that, on average, workers in manufacturing have more market power (to set wages) than their counterparts employed in the service sector. This issue gives way to an extension of this model which adds realism to the labor market. Finally, more research is needed, especially regarding the empirics of structural transformation, as lack of reliable data hampers the ability to test models’ assumptions and predictive power.

A Data description

In this section I describe the data used in this paper. I employ two main data sources with one important difference between them. Data for the United States in Calibrations 1 and 2, are obtained from the Bureau of Economic Analysis (BEA), U.S. Bureau of Economic Analysis (2007), as described below. For Calibration 3, the data used come from the Organization of Economic Cooperation and Development, OECD Statistics Directorate (2007a;b). These two data sources organize industries into sectors differently. The definitions for sectors in the economy are described in Table A.1.

Table A.1: Industrial composition of sectors

Sector	BEA	OECD
Primary:	• Agriculture, forestry, fishing, and hunting; • Mining	• Agriculture, forestry, fishing, and hunting
Manufacturing:	• Manufacturing	• Mining; • Manufacturing; • Utilities; • Construction
Service:	• Utilities; • Construction; • Wholesale trade; • Retail trade; • Transportation and warehousing; • Information; • Finance, insurance, real estate, rental, and leasing; • Professional and business services; • Educational services, health care, and social assistance; • Arts, entertainment, recreation, accommodation, and food services; • Other services, except government	• Wholesale trade; • Retail trade; • Transportation and warehousing; • Information; • Finance, insurance, real estate, rental, and leasing; • Professional and business services; • Educational services, health care, and social assistance; • Arts, entertainment, recreation, accommodation, and food services; • Other services, except government

It is important to note that I chose the first aggregation alternative for my benchmark calibration in accordance with the main assumption in this paper: workers have different market power in different sectors. As I argue extensively in Chapter ??, there is robust evidence that manufacturing workers have higher wages than their counterparts in services. These higher wages arise from imperfect labor markets where workers are able to extract rents from firms.

One way of achieving this goal is to form trade unions. In this regard, Hirsch (2008) shows that unionization rates, the ultimate source of worker market power, have been historically

higher in manufacturing than services or other sectors of the economy. This is depicted in Figure A.1a for the 1973-2006 period.

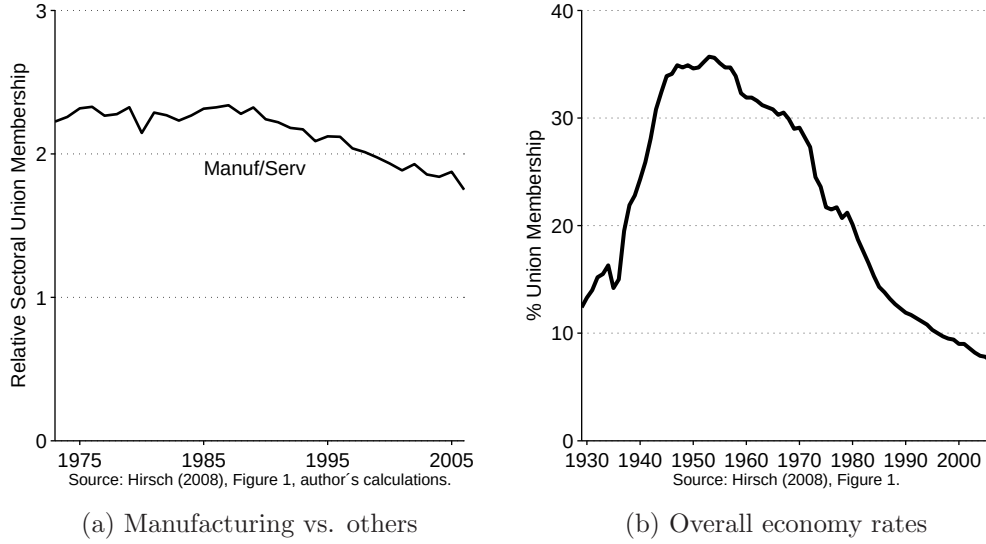


Figure A.1: Union membership and coverage

Moreover, these data shows that unionization rates have decreased over time in all sectors of the economy. In fact, at an aggregate level, the rate has constantly declined since the mid-1950s. Even though this paper does not present a model of unions, but rather uses them as a straightforward way to model market power, it predicts smaller unions over time, consistent with the evidence reported in Figure A.1b. For more on the process of de-unionization in the U.S., see Açikgöz and Kaymak (2008).

A.1 Sectoral output shares

Manufacturing and services output data for the United States come from the *Gross-Domestic-Products-by-Industry Accounts*, U.S. Bureau of Economic Analysis (2007). While *Gross Output* by industry is only available starting in 1987, *Value Added* by industry is available since 1947 in NAICS classification. Hence, to measure sectoral shares in the economy, I use *Value Added* as it allows me trace the last 50 odd years for the United States. Similarly, Duarte and Restuccia (2007) use this approach to approximate sectoral output shares.

Data for European countries come from the Organization for Economic Cooperation and

Development *SourceOECD National Accounts Statistics*, Annual National Accounts - volume I - Main aggregates Vol 2008 release 01. These data are available starting in 1970 for the countries studied.

A.2 Sectoral employment

The data for United States manufacturing and services employment come from the U.S. Bureau of Economic Analysis (2007), *Gross-Domestic-Product-by-Industry Accounts, 1947-2006*. The same grouping for Manufacturing and Services/Construction described in Subsection A.1, Table A.1 is applied to *Full-Time and Part-Time Employees by Industry* to generate employment data.

For European countries, employment data were obtained from the Organization for Economic Cooperation and Development *SourceOECD Employment and Labour Market Statistics*, Labour force statistics - Summary tables Vol 2007 release 01. Time availability and industry grouping into sectors are the same as for the output data.

A.3 Wages/worker payments

The data regarding wages/worker payments come from the BEA *National Economic Accounts*, NIPA Tables. They are constructed by adding these types of income sources: *Wage and Salary Accruals by Industry* (Tables 6.3B,C), *Employer Contributions for Government Social Insurance by Industry* (Tables 6.10B,C), *Employer Contributions for Employee Pension and Insurance Funds by Industry and by Type* (Tables 6.11B,C), and *Nonfarm Proprietors' Income by Industry* (Tables 6.12B,C). According to the BEA Glossary of Terms, (available at <http://www.bea.gov/glossary/glossary.cfm>),

1. *Wage and salary accruals* are the monetary remuneration of employees, including the compensation of corporate officers; commissions, tips, and bonuses; voluntary employee contributions to certain deferred compensation plans, such as 401(k) plans; and receipts in kind that represent income.
2. *Employer contributions for employee pension and insurance funds* are the contributions consisting of employer payments (including payments-in-kind) to private pension and profit-sharing plans, publicly administered government employee retirement plans,

private group health and life insurance plans, privately administered workers' compensation plans, and supplemental unemployment benefit plans, formerly called other labor income.

3. *Proprietors' income* corresponds to the current-production income of sole proprietorships, partnerships, and tax-exempt cooperatives. Excludes dividends, monetary interest received by nonfinancial business, and rental income received by persons not primarily engaged in the real estate business.

The data from 1948 to 1987 are classified in 1972 SIC format while data from 1988 to 2000 are classified in 1987 SIC. Aggregation in large sectors (*i.e.*, manufactures and services) allows me to accommodate industrial classification differences between these two systems.

B Relative wages

B.1 United States evidence

In this section, I report the estimated coefficients for the wage markup. I follow Angrist and Krueger (1999) (see Ricaurte (2009) for details) in employing only male workers to avoid problems with reconstructing earnings profiles of women. The estimates calculated from the sectoral dummy coefficients in are depicted in Figure 1.2b and documented in Table B.1. Details on the data used to generate these parameters as well as the complete output for the wage regressions are available in the companion paper Ricaurte (2009).

It must be noted that all estimated wage differentials are not only statistically significant, but different from one, as reported by their standard errors in Table B.1.

B.2 International evidence

To calibrate relative wages for a broader sample of countries, I use wage markups over the average wage in the economy estimated by Jean and Nicoletti (2002). These authors estimate wage equations *a lá* Mincer to explain industry-level deviations from the economy-wide average wage for 12 developed countries. I could not use Canada, Greece, or Ireland since markup estimates covered only a few industries and a small fraction of the labor force,

Table B.1: Estimated wage ratio

Wage ratio ($\bar{w}^M/\bar{w}^S$), and standard error (in parentheses)							
1962	1.265 (0.033)*	1972	1.167 (0.016)*	1982	1.156 (0.013)*	1992	1.143 (0.014)*
1963	1.201 (0.034)*	1973	1.132 (0.015)*	1983	1.137 (0.014)*	1993	1.116 (0.014)*
1964	1.331 (0.033)*	1974	1.164 (0.016)*	1984	1.146 (0.015)*	1994	1.154 (0.015)*
1965	1.339 (0.032)*	1975	1.159 (0.016)*	1985	1.144 (0.014)*	1995	1.129 (0.014)*
1966	1.309 (0.022)*	1976	1.127 (0.015)*	1986	1.195 (0.015)*	1996	1.15 (0.016)*
1967	1.271 (0.025)*	1977	1.13 (0.014)*	1987	1.148 (0.014)*	1997	1.137 (0.015)*
1968	1.267 (0.018)*	1978	1.145 (0.013)*	1988	1.171 (0.013)*	1998	1.109 (0.015)*
1969	1.237 (0.017)*	1979	1.134 (0.013)*	1989	1.157 (0.014)*	1999	1.132 (0.015)*
1970	1.193 (0.015)*	1980	1.159 (0.012)*	1990	1.165 (0.014)*	2000	1.167 (0.016)*
1971	1.186 (0.015)*	1981	1.153 (0.012)*	1991	1.122 (0.013)*	2001	1.143 (0.016)*
						2002	1.112 (0.012)*
						2003	1.099 (0.013)*
						2004	1.094 (0.013)*
						2005	1.125 (0.014)*
						2006	1.127 (0.014)*
						2007	1.092 (0.014)*
						2008	1.131 (0.014)*

(*): Different from 1 at at the 1% significance level.

and would have yielded biased wage differentials. The equations include industry-level worker characteristics and industry dummies. They interpret the latter coefficients as the “wage markup” deviation; the portion of the relative wage that is not explained by observable worker characteristics.

In my model, I need relative sectoral wages, which are equivalent to relative sectoral markups. To obtain the sectoral relative wages from Jean and Nicoletti (2002)’s industry-level estimates, I aggregate the markups using industry employment data from the Groningen Growth and Development Centre (2006a) and described in Groningen Growth and Development Centre (2006b). The relative wages calculated following this procedure are reported in Table B.2.

Table B.2: Relative sectoral wage: $\frac{w^M}{w^S}$

Sectoral aggregation	U.S. (1998)	Austria (1995)	Belgium (1995)	Italy (1995)	Spain (1995)	Sweden (1998)	U.K. (1995)
BEA*	1.107	-	-	-	-	-	-
OECD*	1.167	1.073	1.019	0.963	1.087	1.011	1.006

(*): Calibration 1, see Table A.1. (★): Calibration 3, see Table A.1.

C Productivity

In a world without capital, productivity is equivalent to output per worker. The value can be calculated with the sectoral output and employment series described in A. To calibrate the productivity parameter in my model to the data (which I denote $\tilde{A}_t^i$), output per worker requires an additional normalization. From conditions (3.14) and (3.15), output per worker (N_t^i) in sector i is:

$$\frac{C_t^i}{N_t^i} = \frac{A^i L_t^i}{N_t^i} = \frac{A^i \int_{h \in \mathcal{H}_t^i} h dF(h)}{N_t^i} = \frac{A^i N_t^i \bar{h}_t^i}{N_t^i} = A^i \bar{h}_t^i,$$

Where $\bar{h}_t^i \equiv E(h|h \in \mathcal{H}_t^i)$ is the average worker productivity in sector i . The expression above shows how to manipulate the output per worker in the data to match overall productivity gains in the model, which come from technological improvements and changes in the quality of workers. Notice that the cutoff level of worker productivity h_t^* determines $\bar{h}_t^i$ and, hence, the actual productivity level in the model.

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