Essays on Structural Change, Trade, and Development

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

Miguel Fernando Ricaurte Bermúdez

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Advisers: Timothy J. Kehoe and Cristina Arellano

May, 2009

Acknowledgements

I would like to acknowledge the role of those persons and institutions without whom the completion of this dissertation and the corresponding doctoral degree, would not have been possible.

My advisers, Timothy J. Kehoe and Cristina Arellano, and my thesis committee members, Fabrizio Perri and Terry Roe, played a direct role with their guidance and invaluable contributions at various stages of my research.

At different phases, my academic career received support from S.C.de.V., Gustavo Arteta, the Corporación de Estudios para el Desarrollo (CORDES), the Konrad Adenauer Stiftung e.V, the Magister en Economía Aplicada at the Universidad de Chile, the Department of Economics at the University of Minnesota, and the Minnesota Population Center at the University of Minnesota.

Finally, the editing and proofreading of this dissertation by Patricia Kelly Hall was critical to the quality of the document.

Dedication
Dedicación

To Gabi, for her continued support and understanding throughout the years.

A Gabi, por su contínuo apoyo y comprensión a lo largo de los años.

To my parents, Vilma and Miguel, whose lives have embodied the importance of hard work in achieving one's life goals.

A mis padres, Vilma y Miguel, cuyas vidas han ejemplificado la importancia del trabajo duro para lograr las metas en la vida.

To my grandparents, Olga and Sócrates, the family's social and emotional cornerstones.

A mis abuelos, Olga y Sócrates, las piedras angulares de la familia en lo social y emocional.

To the people who believed in me at different stages of my professional and personal life, and supported and encouraged me to pursue my goals.

A todas aquellas personas que creyeron en mí en distintas etapas de mi vida profesional y personal, y me apoyaron y alentaron a luchar por mis metas.

Essays on Structural Change, Trade, and Development

by Miguel Fernando Ricaurte Bermúdez

ABSTRACT

The essays in this dissertation employ models of heterogeneous agents or firms to focus on these two aggregate-level issues: (1) structural change and labor market outcomes, and (2) trade and foreign direct investment.

Chapter 1 surveys the literature on industrial and sectoral wage differentials. It begins with a review of the empirical evidence and methods to estimate wage differences. Later, it shows estimates of these differentials for the United States using *Current Population Survey* (CPS) data from 1968 to 2008. The presence of interindustry wage differentials is reported for a number of different specifications. A key finding is that while wage differentials have monotonically decreased for male workers over the period analyzed, the inclusion of female workers disrupts this trend.

Chapter 2 studies the reasons why services became the dominant sector in industrialized economies. I argue that institutional differences which affect the degree of competition in labor and goods markets explain: (a) the rise in the service sector share of output and employment, (b) international differences in sectoral structure, and (c) changes in relative sectoral wages. I use evidence on market imperfections to 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 it happened in the United States and European economies between 1950 and 2000. The model's contribution is to offer an explanation for relative wage differences, in the context of structural change.

Chapter 3 (co-authored with Katherine Lande-Schmeiser) studies the striking differences in industry level data on ratios of exports to sales of foreign affiliates (*i.e.*, FDI sales). We determine what is needed to endogenously generate this pattern of export and FDI sales. By calibrating a model of monopolistic competitive firms, we find that tradability of goods is not enough to capture the observed sectoral differences, as is commonly assumed. We explore variants of the model and show that sector-specific taxes on multinationals and home bias allow us to replicate these differences.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

The sectoral differences in per-capita output growth rates, employment shares, factor and good prices, as well as trade patterns are well documented in the literature. Economists have identified the origin of these differences in technological, institutional, and preference characteristics that are industry- or sector-specific. Understanding these relationships can provide answers to questions such as why has the relative output and employment of the United State's manufacturing sector decreased while wage payments remained higher than in other sectors. While aggregate, multi-sector growth models generate the change in relative output among sectors of the economy, they miss what happens in employment and wages. Therefore, models which include both individuals and firms must be used to address these issues. The essays in this dissertation employ models of heterogenous agents or firms to focus on these two aggregate issues: (1) structural change and labor market outcomes, and (2) trade and foreign direct investment. Specifically, the first and second essays deal with the topic of structural transformation and labor markets, while the third essay studies firms' choice of foreign market servicing (*i.e.*, the choice between exports and foreign production).

The first essay is an empirical analysis of interindustry wage differentials to assess whether labor markets behave in a competitive way. Under the assumption of competitive markets, workers are paid according to their productivity, regardless of their group or industry membership. Thus, wages will differ across sectors or industries only as long as individual characteristics, on average, are different among these groups. This essay is divided into three parts. The first reviews the literature for empirical evidence on interindustry wage differentials. In the second section, I discuss the econometric techniques employed in these empirical studies. In the final part of these essay, I present estimates of wage differentials for the United States between 1968 and 2008.

I begin the literature discussion with papers based only on descriptive statistics analysis. These are followed by a discussion of findings arising from simple Mincer regressions. The last papers discuss employ sophisticated econometric techniques and panel data sets. This review yields three important conclusions. First, the presence of raw interindustry wage differentials is a prevalent feature of developed economies, including the United States, western Europe, and Japan. The second conclusion is that part of this raw wage differences is explained by sectoral differences in observable individual characteristics (*e.g.*, age, education, gender, race). Moreover, a number of studies beginning in the late 1990's report small and unstable interindustry wage differentials when unobserved worker, firm, and employer-employee match quality characteristics are incorporated into the analysis.

The three conclusions drawn above are the result of the evolution of econometric techniques used to estimate wage differentials. The baseline estimates employ Mincer regressions, which are statistical approximations of Becker's human capital model. The idea behind this approach is that wages compensate for human capital, such that human capital-related individual traits must explain wages. A key assumption in the basic Mincer regression is that all human capital-related explanatory variables are included in the equation. However, if observable characteristics such as education, age, gender, and race are not the only determinants of wages, estimated returns to characteristics could potentially be biased. As a concrete example, consider the case in which unobservable worker characteristics are not randomly distributed across industries. Then, if wage differentials are estimated by including an industry-discrete variable, its estimated parameter will be biased in favor of the industry with a higher concentration of unobserved characteristics. To deal with this potential shortcoming, researchers have employed panel data-sets to estimate difference regressions, controlling for unobserved worker characteristics. The idea is that with at least two observations per worker, if unobserved characteristics (namely, ability) are time-invariant, subtracting one period's Mincer equation from its lag will result in the cancelation of the unobserved component, and yield the true interindustry (and human capital) wage returns. The methodology has been extended to include firm-specific characteristics as well as the quality of employer-employee matches when the matched data sets are available, yielding similar results.

In the final part of the essay, I estimate wage differentials for the United States between 1962 and 2008, employing *Current Population Survey* data obtained from the IPUMS-CPS project (King et al. 2008) for those years. Because the data set is not panel data, I must restrict the analysis to standard, year and industry fixed effects estimations of wage differentials. I test a number of specifications for robustness. The main conclusion is that even in the case of deviation-from-the-mean estimates, sectoral wage differentials are present in the United States. More precisely, workers in the manufacturing sector receive higher compensation than equivalent workers in other sectors of the economy. Moreover, this differential is not constant, but rather decreases over the 46 years studied. It must be noted that estimates that include female workers show a less monotonic downward trend than those coming from male workers only. This could be explained by problems with the reconstruction of female workers' carrier profiles, which has been identified in the literature, and the general equilibrium effect of the increase in female participation in the economy. Both these issues remain open research questions from a quantitative theory perspective.

The second essay builds on the empirical evidence provided in the first one to answer the question why have 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 service sector share of output and employment, (b) international differences in sectoral structure, and (c) changes in relative sectoral wages. This last point is particularly relevant, as I argue that this has a major implication for employment allocation. The average wage per worker in manufacturing was higher than in services and increased relative to this sector between 1950 and 2000. However, when corrected for individual characteristics, relative wages showed an overall decreasing trend between 1962 and 2008. These two observations suggest that increasing average wages are the product of improvements in the quality of labor in manufacturing.

Therefore, to analyze sectoral employment and wages, I develop a two sector growth model with imperfect labor markets. I exclude the primary sector from the analysis since it plays only a marginal role in developed economies. 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 less competitive one. The incentive to switch to the latter (*i.e.*, manufacturing in the United States) is the opportunity to engage in bargaining for higher wages. To opt for this alternative, households must pay a fixed cost for bargaining, which results in self selection of households into the two sectors, with the most productive agents choosing to pay the fixed cost and work in the less-competitive sector in exchange for higher wages.

Different sectors in the economy also face different degrees of competition in the goods market as well as different rates of productivity growth. Firms' power in the goods markets implies that they earn positive profits, which in turn provide the rents needed for wage bargaining. Simultaneously, the manufacturing sector has a higher productivity growth rate than services, consistent with empirical observations. This, together with a low elasticity of substitution between manufacturing and services, implies that manufacturing demand for labor decreases over time, such that the average quality of workers in this sector grows. Increasing household productivity results in higher average wages over time. However, as the cost of participating in wage bargaining 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 when corrected for individual characteristics.

Workers' market power is embodied in trade unions; in this study, the presence of of unions is simply meant to capture the workers' market power arising from institutional arrangements. I calibrate the model for the United States' economy and generate the change in sectoral employment and wages, as well output share change, productivity growth, and prices consistent with structural change. I show that a model with no wage-bargaining cannot replicate actual employment and wage trends, and requires a counterfactual elasticity of substitution between manufacturing and services to generate equivalent output share changes. Moreover, I fit the 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 essay contributes to the literature by offering 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 or employing non-homothetic preferences, used in the existing literature.

The third and final essay, co-authored with Katherine Lande-Schmeiser, studies firms' choices of foreign market servicing. Industry-level data show striking differences among sectors in the ratio of exports to sales of foreign affiliates (which we refer to as FDI sales). In this essay we test if tradability (*i.e.*, ease of trade) and home bias can explain these endogenous and large sectoral differences in the choice of foreign market servicing. We derive a multi-country, multi-sector general equilibrium model of monopolistic competition where heterogenous firms choose to service a market through either exports or the establishment of a foreign affiliate. Using sectoral data on bilateral trade, FDI sales, employment and costs for Canada and the United States, we test whether the tradability of goods can capture the observed variations described above.

We find that a measure of tradability alone is insufficient to determine the ratio of exports to FDI sales. This does not come as a surprise since we reported there is no strong relationship between the ratio of exports to FDI sales and the tradability index. Moreover, we show there is no direct relationship between this index and total sector sales. We argue that allowing other dimensions of the model to be sector-specific, the explanatory power of the model improves. Hence, we discuss five variants on a model of monopolistic competition, where we allow for elements such as sector-specific fixed costs, sector-specific firm productivity dispersion, sales taxes, and home product bias in the utility function to be different among sectors. We find that sector-specific fixed costs and productivity dispersion are not sufficient to explain the observed differences in exports and FDI sales. However, sector-specific sales taxes on the operations of foreign affiliates and sector-specific home product bias do provide an explanation. The latter gives more realistic results because the sales tax model requires implausible rates in some sectors of the economy.

Chapter 2

Interindustry wage differences: an empirical review

2.1 Introduction

Under the assumption of perfectly competitive labor markets, workers should be compensated according to how productive they are. The neoclassical framework allows for wage dispersion as long as workers' productivity levels, and the productivity of the firms they work in, differ. Never-the-less, as early as sixty years ago Slichter (1950) and Weiss (1966) documented that wage differentials among workers are a prevalent feature of labor markets. These papers not only pointed at the presence of *raw* wage differences, but also showed that these differentials subsist even after observable individual differences are taken into account. In particular, characteristics such as education, age, and tenure on the workers' side, and size, profitability, and sales on the firms' side, play an important role in explaining wage differentials.

As a companion to Ricaurte (2008), this paper has three different purposes. First, it reviews the existing literature for empirical evidence on wage dispersion, with an emphasis on sectoral and industrial wage differences. To solve the puzzle of these types of wage premia, a number of theoretical explanations arose, ranging from search models, to the presence of collective bargaining schemes.[1] The first analysis concentrates on these

[1]See Cahuc and Zylberberg (2004) for a discussion.

qualitative results. The statistical and econometric strategies developed to empirically test the presence of wage dispersion are treated separately in the second review. It is important to note that these econometric techniques have advanced alongside the quality of data sets. In particular, modern methodologies require linked panel data sets, which became available beginning in the 1980s. Since the robustness of these methods has improved over time, it is important to discuss the literature and methodology in a chronological context. The final purpose of the paper is to present my own estimates of interindustry wage differentials for the United States using Current Population Survey (CPS) data.

I begin the empirical analysis by reporting first and second moments of the data and discussing raw group wage gaps (*e.g.*, gender, race, urban-rural). My findings are consistent with those discussed extensively in Katz and Autor (1999) and Lee and Wolpin (2006). I find that overall inequality in earnings has increased over the period studied, with the primary and service sectors showing the largest inequality. My econometric estimates allow me to conclude that a "true" wage gap exists. Moreover, when I aggregate industries into major sectors, I find that wage differentials favoring manufacturing over services are prevalent (and statistically significant) throughout the 1968-2008 period. Here, too, the gap is not constant. While the estimates for all workers grew from the early 1970s to the late 1980s and later decreased, the equivalent gap estimated for male workers only, monotonically decreases in the period studied. Explaining these observations requires attention beyond the scope of this paper.

The paper is structured as follows: In Section 2.2 I review the relevant literature on empirical evidence of intra-industry wage differentials. The discussion in this section concentrates on regularities reported in the data and their evolution over time; methodological considerations are discussed in section 2.3. These two sections lay the background for interindustry wage differential estimates based on CPS data for the United States from 1968 to 2008, presented in Section 2.4. This section includes a abridged description of the data, the (econometric) estimation strategy, and a discussion of the results. Details on the data as well as the estimates appear in the appendices. Finally, concluding remarks are presented in Section 2.5.

2.2 Empirical evidence (literature review)

In this section, I review the relevant empirical literature and discuss the existing evidence on wage differentials across groups (industries and sectors, in particular), beginning in the second half of the twentieth century. Change in the qualitative aspects of the empirical evidence on wage differentials is due both to improvements in methodology as well as the availability of relevant data sets. I begin with research describing the basic descriptive statistics and work through the literature to conclude with a discussion of research employing sophisticated econometric techniques and employer-employee linked data sets. Although this section surveys a large body of the relevant research, it is not feasible to be exhaustive given the volume of the existing literature.

The issue of wage differentials was documented as early as 60 years ago by Slichter (1950) and Weiss (1966). These two papers pioneered this branch of labor economics relying on descriptive statistics analysis alone. As quantitative – statistical – tools were incorporated into economic analysis, researchers were able to control for worker and firm characteristics to explain wage differentials. Thus, two views regarding measured interindustry wage differentials appeared: (1) true wage differentials exist across industries; and (2) the measured differentials simply reflect unmeasured differences in workers' productive abilities, in firm characteristics, and in the quality of the employer-employee match.

The quantification of income differences among individuals employs a basic framework first proposed by Jacob Mincer to study human capital and its impact on earnings (Mincer 1958; 1974). This framework, known as the *Mincer equation* or *regression*, relies on the simple idea proposed by Gary Becker (1964) that changes in individual characteristics through the life cycle contribute to higher income.[2] The original hypothesis was that income differs among individuals contingent on differences in qualities affecting labor productivity (*i.e.*, human capital stock). Never-the-less, early literature shows that even after controlling for these productivity-related individual characteristics, differences in income prevailed. In other words, wage discrimination seemed a reality.

The most commonly identified forms of group discrimination were those related to race and gender. The literature on discrimination is large, but will not be discussed

[2] For a detailed discussion on the evolution of Mincer regression methodology and applications, see Heckman et al. (2003).

here as it is beyond the scope of this review. However, two classical references at the foundation of group wage differentials deserve special attention. In separate papers, Blinder (1973) and Oaxaca (1973) proposed a simple way to decompose average wage differentials into two sources: differences in group characteristics and "true" discrimination (*i.e.*, different returns to similar characteristics). Using the *Survey of Economic Opportunity* for 1967, both authors find that even after controlling for observable human capital characteristics (*e.g.*, education, experience, class of worker) wage differences between male and female workers, as well as white males, black males, and white females, persisted. In other words, it is not the difference in human capital stock that explains wage differences across genders and race, but rather true discrimination. Moreover, the method of wage decomposition (described in Section 2.3 below) allowed the authors to isolate the characteristics that suffered discrimination.

The idea of group discrimination is closely related to sectoral (and industrial) wage gaps. Among the first studies to address this for the United States is Krueger and Summers (1988). Employing cross-sectional and longitudinal data from the *Current Population Survey* (CPS) and QES, they categorically reject the hypothesis that labor markets behave competitively. They find large differences in wage dispersion across sectors as well as evidence of wage differentials, as measured by statistically significant industry dummies in Mincer equations. The authors argue that this differences cannot be tied to unobserved individual characteristics or pecuniary motives for job compensation. Even controlling for unobserved characteristics, they find significant wage differentials similar to those obtained from an estimation with no individual fixed effects. The study also finds that firm size matters for wage structure and that worker turnover is negatively correlated to wage differentials. The authors argue that this is evidence that workers in high wage industries earn non-competitive rents.

These results are corroborated by Gibbons and Katz (1992), a study which employ CPS data. Here the authors assert that "true" wage differentials exist across industries based on two arguments. First, they find estimates that do not control for unmeasured abilities fit the data as well as those employing individual fixed effects. Second, their estimates show that wage gains of workers who switch industries are equivalent to differentials estimated in a cross-section. Thus, they conclude wage differences across industries cannot arise primarily from unobserved worker characteristics.

The evidence on interindustry wage differentials is consistent with the presence of wage dispersion in the United States. Whether this is a prevalent feature in all economies remains an open question. A number of studies address this issue by contrasting the United States labor market with its European counterparts. For example, Holmlund and Zetterberg (1991) report that wages are more dispersed in the United States than in Sweden, Norway, Finland, and Germany. From these findings they conclude that there is a higher sensitivity of wages to sectoral price and productivity changes in the United States. Never-the-less, they do not offer an explanation for the phenomenon.

Kahn (1998) goes a step further by establishing a connection between collective bargaining (more prevalent in Europe than the United States) and wage dispersion. Employing microdata from several sources[3] and quantile regressions, he compares the wage experiences of the United States, Britain, West Germany, Austria, Sweden, and Norway in the 1980s. The paper reports high interindustry wage differentials and a union-wage premium in the United States than Europe. The author argues that the prevalence of collective bargaining in Europe has compressed wages there. In a related paper, Açikgöz and Kaymak (2008) study the process of de-unionization in the United States, arguing that wage compression arising from collective bargaining becomes a disincentive for workers to join a union.

It is clear that by the end of the 1990s, many scholars had embraced the presence of "true" wage differentials. Yet, Abowd et al. (1999) and Goux and Maurin (1999) disputed this hypothesis by use of employer-employee matched data for France and the United States. Goux and Maurin (1999) estimate Mincer regressions with no omitted variables (unobservable characteristics) and cannot reject the hypothesis of sectoral wage differentials in France between 1990 and 1995; this is consistent with Krueger and Summers (1988). Moreover, the industries with higher/lower wage markups are similar in both the United States and France, even though labor markets are considered to be different.

Next, Goux and Maurin (1999) estimate a model with individual fixed effects to control for unobserved individual characteristics. Their results support their claim that interindustry wage differentials are largely explained by unobservable characteristics.

[3] Data sources include, among others: PSID, CPS, and International Social Society Survey Program data. Details on the data sources can be found in the paper.

Unlike Gibbons and Katz (1992), they show that workers who switch industries experience small and time-unstable wage gains. Wage differentials are caused by unmeasured abilities that are not evenly distributed across industries. The authors also instrument the industry choice and find no strong evidence of endogeneity, thus reinforcing their finding of small "pure" interindustry wage differentials. Moreover, the authors explore the impact of firm-specific wage policies on interindustry wage differentials by estimating a model with worker and firm fixed effects. Unlike Abowd et al. (1999), Goux and Maurin (1999) find significant interfirm wage differences, although there is low correlation between the distribution of workers and firms' wage policies in France.

The correlation between workers and firms' wage policies discussed in the studies above is a branch of the literature in itself, and merits at least a brief discussion. Abowd et al. (1999) explored this margin for France; more recently, Arai (2003) used Swedish employer-employee matched data with the same goal. After controlling for worker quality, degree of effort supervision, job characteristics, local unemployment, firms' employment history, and employer size, the author finds that wages are positively correlated with profits and the capital-labor ratio of firms. He concludes that workers with more experience and education are sorted into more profitable firms. Moreover, the author estimates that between 12 and 24 percent of the mean wage in Sweden corresponds to rent sharing, similar to estimates for the United States and the United Kingdom. For the United States, Brown and Medoff (2003) use Survey Research Center's monthly Survey of Consumers from the University of Michigan, and find that the raw relationship between firm age and wages is positive. However, after controlling for individual characteristics, they conclude the relationship is insignificant.

Turning back to interindustry wage differentials, the work of Jean and Nicoletti (2002) addresses the issue of wage differentials for a sample of twelve OECD countries. Using average statistics for 41 industrial groups, the authors find significant industry markups for OECD countries by estimating a two-step econometric procedure. The first step generates statistically significant sectoral wage differentials from Mincer equations for each country. These markups are then regressed against market and policy characteristics in each sector. The authors conclude that labor and good market regulations have an important impact on sectoral wage differentials. It should be also noted that, unlike Goux and Maurin (1999), this paper finds that industries which have the highest markups vary across countries.

A final paper is at the frontier in terms of methodology and the data set employed. Woodcock (2008) used the U.S. Census Bureau's Longitudinal Employer-Household Dynamics (LEHD) database which tracks workers and firms and therefore, employer-employee relationships over time. The author controls for observable and unobservable characteristics in these three dimensions to quantify interindustry wage differentials. By adding unobserved employer-employee match effects, this paper exposes the potential problems of excluding them. The authors argue that while a model *a la* Abowd et al. (1999) provides some information on worker and firm effects on wages, the interaction of these two is critical in explaining wage differentials. An application to linked employer-employee data shows that decompositions of interindustry earnings differentials and the male-female differential are misleading when unobserved heterogeneity is ignored.

2.3 Methodological review

Having discussed the main empirical regularities reported in the literature, in this section I review the evolution of the methods employed to reach those conclusions. I argue that the data available (in particular, cross sections vs. panel data sets) play a determinant role in the application of each methodology. The challenge is to understand the source of the difference in a measure of average income (*e.g.*, wages) between some group j of individuals and a reference group 0. The **raw wage differential** between such groups can be written as: $\log \overline{w}_j - \log \overline{w}_0$. Groups identify specific characteristics such as race, gender, or industry; examining this last factor is the concern of this paper.

When the data available corresponds to a cross section of individual observations, the simplest way to address income differences is to assume there are different income outcomes depending on the group membership. In particular, let the income outcome for individual i in the reference sector 0 be:

$$\log w_{i,0} = \mathbf{x}_i'\mathbf{B} + \epsilon_i,$$

where $\mathbf{x}_i$ is a vector of the observable or measured characteristics of individual i, and the outcome in sectors $j \neq 0$:

$$\log w_{i,j} = \log w_{i,0} + \theta_j.$$

In the expressions above I have assumed that there are constant, but potentially different, wage differences (θ_j) between sectors j and the reference sector 0, but returns to individual characteristics are common across them. The combination of these expressions gives the regression estimated for individual i:

$$\log w_i = \mathbf{x}_i'\mathbf{B} + \gamma_i'\Theta + \epsilon_i, \tag{2.1}$$

where γ_i is a vector of indicator variables for group membership, Θ is a vector composed of θ_j's, and ϵ_i is an independent and identically distributed error term with variance σ_ϵ^2. In the case of sectoral wage differentials, the vector γ_i identifies the industry or sector of the economy where the individual works. To test the hypothesis that labor markets are competitive under this formulation, I test whether the coefficients in $\boldsymbol{\Theta}$ are simultaneously zero.

The average wage differential between sector j and reference sector 0 can be written as:

$$\log \overline{w}_j - \log \overline{w}_0 = \underbrace{(\overline{\mathbf{x}}_j - \overline{\mathbf{x}}_0)'\hat{\mathbf{B}}}_{(1)} + \underbrace{(\hat{\theta}_j - \hat{\theta}_0)}_{(2)}, \tag{2.2}$$

where the overbars indicate group averages and the hats denote estimated parameters. Equation (2.2) decomposes wage differentials into (1) the difference in average individual characteristics and (2) differences intrinsic to group membership. Krueger and Summers (1988) and Katz and Autor (1999) study interindustry wage differentials under this formulation, as do the benchmark models of Goux and Maurin (1999) and Abowd et al. (2008), among others. The review of the importance of firm-size on wage differentials by Oi and Idson (1999) shows that this is a popular econometric approach in this branch of the literature, echoed by Abowd et al. (1999), among others.

A generalized version of equations (2.1) and (2.2), known as the Blinder-Oaxaca decomposition method (Blinder 1973 and Oaxaca 1973), allows all parameters, *i.e.*, the constant as well as the returns to worker characteristics, to differ across sectors. To see the difference between the Blinder-Oaxaca decomposition and the model represented by equation (2.2), I write wage differentials between sector j and reference sector 0 as:

$$\log \overline{w}_j - \log \overline{w}_0 = \underbrace{(\overline{\mathbf{x}}_j - \overline{\mathbf{x}}_0)'\hat{\mathbf{B}}_{\mathbf{0}}}_{(1)} + \underbrace{\overline{\mathbf{x}}_j'(\hat{\mathbf{B}}_{\mathbf{j}} - \hat{\mathbf{B}}_{\mathbf{0}})}_{(2)}, \tag{2.3}$$

where the vector $\mathbf{B}$ now contains the constant term in the regression (term θ in (2.2)) and vector $\mathbf{x}$, the group the individual works in. The righthand side of equation (2.3) shows (1) the sectoral differences in average characteristics, and (2) differences in returns to those characteristics across sectors. In the labor economics literature, the first term is referred to as the "explained component" of wage differentials, since it comes from variations in observable worker characteristics across sectors.

Statistically speaking, the estimation of models such as the ones described by equations (2.2) and (2.3) is correct under the assumption that the error term is uncorrelated with the vectors $\mathbf{B}$ and $\boldsymbol{\Theta}$ of parameters. This assumption is prone to fail when individual characteristics are omitted from the regression equation. Therefore, in the presence unobserved individual characteristics, the estimates of returns to individual characteristics or group membership will be biased. In particular, if workers of different abilities are not randomly (or evenly) distributed across firms or sectors, the parameter associated with the industry indicator variable will capture this difference in ability distribution.

The problem of unobserved individual characteristics has been extensively diagnosed and addressed in the literature when panel datasets are available. In particular, the classical solution exploits repeated individual observations to control for unobserved individual characteristics (see Angrist and Krueger 1999 for a complete survey). The correct specification is not equation (2.1), but rather an **individual fixed effects model**. This family of models is meant to control for unobserved, time invariant characteristics that affect the – dependent – income variable and which can be correlated to other independent, explanatory variables.

For example, when wages only differ through a constant term (*e.g.*, equation (2.1)), the regression to be estimated for every time t is:

$$\log w_{i,t} = \mathbf{x}'_{i,t}\mathbf{B} + \gamma'_{i,t}\Theta + \alpha_i + \varepsilon_{i,t}, \tag{2.4}$$

where α_i represents individual i's unobserved characteristics and $\varepsilon_{i,t}$ is uncorrelated with $\mathbf{x}_{i,t}$. These characteristics (presumably related to ability) are assumed to be time invariant. Therefore, I can control for them taking the first difference of (2.4) to obtain:

$$\triangle \log w_{i,t} = (\mathbf{x}_{i,t} - \mathbf{x}_{i,t-1})'\mathbf{B} + (\gamma_{i,t} - \gamma_{i,t-1})'\Theta + \eta_{i,t}, \tag{2.5}$$

and $\eta_{i,t} \equiv \triangle\varepsilon_{i,t}$ is the uncorrelated error term. The possibility that industry choice is an endogenous decision poses a problem to estimating equation (2.5).

To address the endogeneity issue, Goux and Maurin (1999) apply a test proposed by Murphy and Topel (1987), that relies on the possibility of identifying workers in a panel dataset who have switched industries from those who have not. Then, they the compute interindustry wage differentials for "non-switchers," and estimate how much of this difference is gained by "switchers" (*i.e.*, workers who choose to switch).[4] The equation estimated is:

$$\triangle \log w_{i,t} = (\mathbf{x}_{i,t} - \mathbf{x}_{i,t-1})'\mathbf{B} + \delta(\gamma_{i,t} - \gamma_{i,t-1})'\Theta_0 + \eta_{i,t}, \tag{2.6}$$

where Θ_0 is the vector of cross-sectional interindustry wage differentials measured for non-switchers, and δ is the fraction of those differentials experienced by switchers. If this parameter is close to one, then wage differentials are pure "interindustry" differentials, whereas if it is closer to zero, all wage differences are due to labor quality. The authors estimate δ with OLS and instrumental variables (employing the pre-switch industry as instrument) and find that both procedures yield a low and statistically equivalent δ. They conclude that endogeneity of mobility does not constitute a major source of bias.

An alternative to the time differences approach (such as equations (2.5) and (2.6)) consists of estimating deviations from individual observation means. This approach can

[4]This formulation resembles that of a **differences-in-differences** estimation procedure, which is applied in cases when certain groups are exposed to the influence of an event and other are not. This methodology is outside the scope of this paper as its main application is to measure the impact of policy or other economic environment changes. For more details, see Angrist and Krueger (1999).

be applied when parameter vectors $\mathbf{B}$ and $\boldsymbol{\Theta}$ are time-invariant, such that individual unobserved characteristics α_i are eliminated when OLS is applied to the difference equation:

$$\log w_{i,t} - \log \overline{w}_i = (\mathbf{x}_{i,t} - \overline{\mathbf{x}}_i)'\mathbf{B} + (\gamma_{i,t} - \overline{\gamma}_i)'\Theta + (\varepsilon_{i,t} - \overline{\varepsilon}_i), \tag{2.7}$$

where overbars denote person averages. Angrist and Krueger (1999) argue that this model is preferable to time differences on efficiency grounds.

The models discussed so far assume that only individuals have unobserved characteristics; in many papers reviewed, this is the result of data restrictions. However, these **individual fixed effects** models can be extended to include **firm fixed effects** and **match fixed effects** when employer-employee matched panel data are available. Even though some effort was made in the 1960's and 1970's to generate these data sets, it was only in the 1980's that the French National Institute for Statistics and Economic Studies (INSEE) generated the first robust surveys (Abowd and Kramarz 1999). By the end of the 1990's, Abowd and Kramarz (1999) report the existence of 38 such data sets for 17 countries and just a handful of econometric papers using them. Representative studies employing French data are Goux and Maurin (1999), Abowd et al. (2006), and Abowd et al. (2008). For the United States, it was not until the beginning of the 2000's that the *Integrated Longitudinal Employer-Employee Data* were made available by the U.S. Census Bureau (as Abowd et al. 2004 document). A recent example employing the U.S. match data to estimate wage differentials is Woodcock (2008).

The idea behind extending the individual fixed effects model is that there are unobservable firm (*e.g.*, specific wage policies) or employer-employee pair (*e.g.*, match quality) characteristics that bias wage gap estimates. When employer-employee matched panel data are available, workers, establishments, and worker-establishment matches can be tracked over time; these unobservable characteristics can be then dealt with in the same manner as an individual fixed effects model. A general version of the model, following equation (2.4) and Woodcock (2008) is:

$$\log w_{i,k,t} = \mathbf{x}'_{i,t}\mathbf{B} + \mathbf{z}'_{k,t}\mathbf{C} + \gamma'_{i,t}\Theta + \alpha_i + \psi_k + \phi_{i,j} + \varepsilon_{i,k,t}, \tag{2.8}$$

where income of worker i in firm k at time t is assumed to depend on observable individual ($\mathbf{x}_{i,t}$) and firm ($\mathbf{z}_{k,t}$) characteristics, the sector the worker is employed in (θ_k), and unobserved individual (α_i), firm (ψ_k), and employer-employee match characteristics ($\phi_{i,j}$). Notice that observable match characteristics implicitly appear in vectors $\mathbf{x}_{i,t}$ and $\mathbf{z}_{k,t}$, and could appear as interaction terms as well.

Income in equation (2.8) can be decomposed in the same fashion as the preceding formulations. The general econometric strategy is to estimate the differenced equation, where match and firm effects appear as indicator variables. The effect of estimating a regression which omits unobserved firm, match, or both effects is discussed extensively in Woodcock (2008).[5]

In addition to the fixed effects formulations described above, unobserved characteristics can be of two forms. First, regressions with **between effects** are employed to control for omitted variables that change over time but are constant between groups. This approach allows a researcher to use the variation between cases to estimate the effect of the omitted independent variables on the income. Moreover, when it is plausible that some omitted variables are constant over time but vary between groups (**fixed effects**), and others are fixed between groups but vary over time (**between effects**), then both types can be included by using a **random effects** model.

Choosing between the different formulations is done by running a Hausman test. Statistically, **fixed effects** are generally reasonable with panel datasets since they always give consistent results, but they may not be the most efficient model. On the other hand, a **random effects** model yields better p-values (*i.e.,* they are a more efficient estimator), so it should be used when it is statistically justifiable to do so. The Hausman test contrasts a more efficient model against a less efficient but consistent model to make sure that the latter also gives consistent results. For a detailed discussion on the topic, see Wooldridge (2002), chapters 10 and 11.

2.4 Wage differentials in the U.S.: CPS estimates

This section discusses the empirical aspects of interindustry wage differentials employing CPS data obtained from King et al. (2008). I begin by describing the data and presenting

[5]This discussion is omitted from the paper due to its technical nature and the fact that this procedure will not be applied in the empirical estimates in Section 2.4.

comparative statistics, and then evaluate the econometric estimates of wage differentials.

2.4.1 Data description

The estimates presented here employ data from the March Current Population Survey (CPS), as provided by the IPUMS-CPS project (King et al. 2008). The main advantage of employing the IPUMS-CPS version of the data is that variables have been integrated (*i.e.*, made comparable) across long periods of time. It is particularly important to note that despite of this obvious advantage, comparability issues may arise from question wording, the universe of individuals surveyed, and changes in group classifications. Data availability and the universe descriptions for the original variables used in this estimation exercise can be found in Table 2.7, in Appendix 2.A. Technical details on the CPS data, such as sampling procedure, weights, and other issues are available from IPUMS-CPS, at http://cps.ipums.org/cps/samples.shtml.

I analyze income differentials using two alternative variables: total wage and salary income and hourly wages. The first variable reports the respondent's total pre-tax wage and salary income for the previous calendar year, hereafter referred to as wage/salary income. The second captures the amount the respondent earned per hour in the job she held at the time of the survey, for those workers who were paid an hourly wage. Besides the obvious differences between these two income measures, it should be noted that hourly wage data were not collected from self-employed workers and is only available starting in 1990, while wage income data is available starting in 1962.

It is also important to note that the industrial classification has evolved five times between 1962 and 2008, the longest stretch of time for which CPS data are available. To include as many years of data as possible in the analysis, minor industries are aggregated into sectors to avoid comparability issues across years. For this reason, and unless otherwise noted, I restrict analysis to the 1968-2008 period. During this time, industry-level data are comparable through the IPUMS-CPS harmonized variable IND1950. This variable uses the 1950 Census Bureau industrial classification system for all years.

Three data sets are available for this analysis, as described in Table 2.1. Notice that the first data set can be restricted to the 1990-2008 period for comparison with the second data set. Since alternate data sets present the opportunity for a more complete analysis, I will constantly compare estimates arising from them. Mincer equations

Table 2.1: Data sets

Period	Income measure	Minor industries	Major sectors
1968-2008	Wage income	comparable	comparable
1990-2008	Hourly wage	comparable	comparable
1962-2008	Wage income	not comparable	comparable

ideally are estimated over hourly wages (as opposed to gross wage income), which makes the second data set empirically appealing. As a companion to Ricaurte (2008), one of the main objectives of this paper is to provide wage differential estimates for the longest stretch of time possible. This implies using the second data set, which only allows me to compare major economic sectors. Data will be organized into the industrial sectors described in Table 2.2. [6]

Table 2.2: Major and minor industries

A	Agriculture, Forestry, and Fishing	
B	Mining	
C	Construction	
D	Manufacturing	
	D1	Durable Goods
	D2	Non-durable Goods
E	Transportation, Communication, and Other Utilities	
	E1	Transportation
	E2	Telecommunications
	E3	Utilities and Sanitary Services
F	Wholesale and Retail Trade	
	F1	Wholesale Trade
	F2	Retail Trade
G	Finance, Insurance, and Real Estate	
H	Business and Repair Services	
I	Personal services	
J	Entertainment and Recreation Services	
K	Professional and Related Services	

Letters correspond to Table 2.8.
Source: IND1950, IPUMS-CPS, King et al. (2008).

Table 2.3 shows descriptive statistics for selected years. These data are organized into four sectors: (1) primary, (2) manufacturing, (3) services, and (4) construction

[6] Estimates employing the third data set require a high level of industrial aggregation to be comparable across time. They are only discussed in Appendix 2.E to this paper.

and utilities.[7]. Unless otherwise noted, the data correspond to fulltime workers either employed as wage/salary workers in the private sector or self employed workers. Panel A contains the distribution of workers across sectors and the number of observations for each year. Current-price wage and salary income appears in panel B. It is clear that in raw terms, average income in the manufacturing sector (2) is higher than in other sector. As discussed in the literature and methodology review sections, differences in the characteristics of workers are partially responsible for these wage differences.

Table 2.3: Descriptive statistics, selected years

	A Sectoral composition (%)					**B Wage/salary income, current $**				
Year	**(1)**	**(2)**	**(3)**	**(4)**	**Obs.**	**(1)**	**(2)**	**(3)**	**(4)**	**All**
1968	2.81	41.16	47.94	8.09	35,395	4,761	6,453	5,629	6,869	6,044
1978	3.07	34.79	53.84	8.31	39,524	10,266	12,555	11,357	13,261	11,899
1988	3.00	27.69	60.59	8.72	45,282	18,589	24,321	21,755	23,466	22,520
1998	2.65	22.65	66.06	8.63	40,361	25,947	36,533	34,734	34,704	34,906
2008	2.89	16.08	71.09	9.94	60,521	37,721	53,233	49,493	44,485	49,257
	C Female workers (%)					**D Average age**				
Year	**(1)**	**(2)**	**(3)**	**(4)**	**All**	**(1)**	**(2)**	**(3)**	**(4)**	**All**
1968	7.95	26.74	41.52	5.38	31.57	40.09	39.85	39.68	39.27	39.73
1978	13.50	28.97	43.50	7.03	34.50	36.05	38.32	36.81	36.64	37.29
1988	16.69	31.27	48.09	9.10	39.09	36.64	38.26	36.71	36.35	37.11
1998	17.67	30.79	48.62	9.66	40.40	38.18	39.92	38.76	38.44	38.98
2008	16.73	28.75	48.83	9.59	40.77	40.10	42.91	40.99	39.95	41.17
	E Black workers (%)					**F College graduates (%)**				
Year	**(1)**	**(2)**	**(3)**	**(4)**	**All**	**(1)**	**(2)**	**(3)**	**(4)**	**All**
1968	14.26	8.75	10.53	9.76	9.84	4.19	7.83	10.82	4.16	8.86
1978	8.09	10.04	9.07	6.95	9.20	9.52	11.10	17.81	7.95	14.40
1988	5.94	10.15	10.18	7.89	9.84	15.06	18.07	24.83	10.41	21.41
1998	4.25	10.92	11.74	7.72	11.01	12.79	20.26	29.03	11.35	25.09
2008	3.97	9.31	11.87	5.27	10.57	12.13	27.49	34.62	12.92	30.67

Sectors are: (1) primary, (2) manufacturing, (3) services, and (4) construction and utilities. For detailed composition, see Table 2.5.
Statistics for all years available in Appendix 2.C, Table 2.9.
Source: Author's calculations, IPUMS-CPS, King et al. (2008).

[7]For a detailed description, see Table 2.5, Option 4. Full details on sectoral composition can be found in Appendix 2.B, Table 2.8

It is noteworthy that the fraction of female workers is higher in services (3), as shown in panel C; this could account for the lower average income in this sector.[8] The average age across sectors does not differ significantly (panel D). The presence of African-American workers is higher in manufacturing (2) and services (3) than in the other sectors (panel E). Finally, from panel F it is clear that the fraction of workers with a college degree or higher has been historically higher in services (4) than in any other sector; this gap has remained fairly stable over the 41-year period. It is not immediately clear why income in manufacturing is higher than services.

Table 2.4: Descriptive statistics, 1990-2008

	A Hourly wage, current $					**B Union coverage (%)***				
Year	**(1)**	**(2)**	**(3)**	**(4)**	**All**	**(1)**	**(2)**	**(3)**	**(4)**	**All**
1990	6.86	9.40	7.35	11.07	8.16	11.50	31.24	10.44	27.08	16.96
1991	8.82	9.65	7.66	11.85	8.50	*22.04*	30.02	10.94	33.47	17.63
1992	7.50	9.97	7.98	11.82	8.70	11.73	29.02	10.86	29.71	16.38
1993	7.93	10.00	8.31	11.93	8.95	10.30	26.89	10.85	27.84	15.71
1994	9.35	10.50	8.71	12.11	9.36	12.01	27.88	11.17	28.07	16.14
1995	8.49	10.64	8.82	12.57	9.49	10.95	26.75	9.50	27.51	14.62
1996	8.36	10.84	8.87	12.02	9.55	11.11	25.86	10.04	23.26	14.64
1997	9.77	10.97	9.02	13.09	9.79	4.72	24.19	9.16	25.99	13.71
1998	9.54	11.75	9.66	14.03	10.45	6.48	23.03	9.33	25.64	13.45
1999	9.21	12.27	10.25	13.81	10.93	5.14	22.30	10.18	25.48	13.78
2000	8.61	12.69	10.69	14.25	11.37	4.32	20.29	9.41	25.08	12.89
2001	9.92	12.94	11.03	15.06	11.75	*10.21*	20.78	9.25	26.79	13.02
2002	10.09	13.48	11.39	15.29	12.06	5.36	23.12	9.37	25.84	13.17
2003	10.64	13.85	11.87	16.02	12.51	4.37	19.29	8.91	24.54	11.86
2004	10.81	14.30	12.03	16.55	12.76	4.73	19.33	8.59	23.42	11.55
2005	11.24	14.63	12.28	15.65	12.95	5.55	20.16	8.53	15.97	11.09
2006	12.99	14.95	12.62	16.63	13.39	6.37	17.22	7.43	20.12	10.21
2007	11.95	15.31	13.30	16.91	13.94	5.40	17.93	8.03	19.42	10.65
2008	13.50	15.87	13.73	18.01	14.40	6.01	16.96	8.58	20.96	10.74

⋆: Includes union members and covered non-members.
Source: Author's calculations, IPUMS-CPS, King et al. (2008).

When analyzing hourly wage, the universe of workers includes those wage/salary workers paid by hour, excluding self-employed workers. This variable, as well as union coverage, is only available starting in 1990 in CPS data. Average, current-price wages

[8] Moreover, these numbers are consistent with a lower female participation in the labor market compared to males. Likewise, the figures reported here indicate that female participation increased in the 41-year time period studied.

by sector and year appear on the left panel of Table 2.4. Union coverage, defined as union membership plus non-members covered by union-related contracts, is reported on the right panel of Table 2.4. Construction and utilities (4) present the highest wages and union coverage rates, followed by manufacturing (2), services (3), and primary (4) sectors. Two remarks on the rate of union coverage are required. First, the observations for 1991 and 2001 in the primary sector (1) are suspect for measurement or sampling error since they are twice as large as the values in the adjacent years. Second, union coverage shows a decreasing trend in all sectors, consistent with that reported in Hirsch (2008).[9]

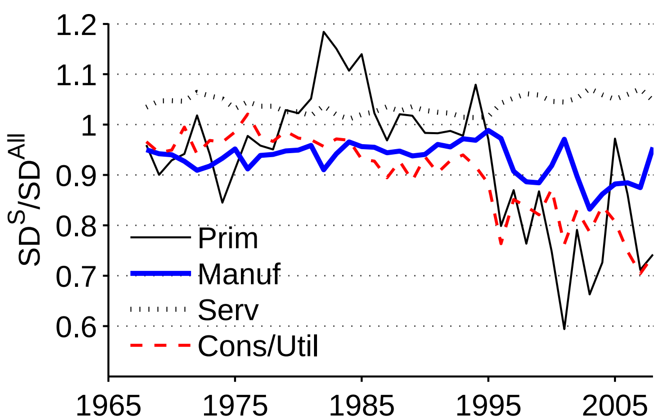


Figure 2.1: Sectoral wage/salary income SD relative to sample

The final are of discussion is the evidence of wage dispersion in the data for wage/salary income. The literature identifies wage dispersion to be related with increases in average income. Moreover, Açikgöz and Kaymak (2008) and others report that wages are compressed in scenarios where some form of collective bargaining (*e.g.*, through unions) is prevalent. I present two indicators of sectoral differences in wage dispersion for the data. The first is the relative standard deviation of wage/salary income in each sector with respect to the sample standard deviation presented, by year, in Figure 2.1. The data in the graph come from estimates on the four sectors described in Table 2.5, option 4. It should be noted that wage dispersion in manufacturing is consistently higher than that of the overall economy between 1968 and 2008. Conversely, the standard deviation of

[9] Actual union coverage percentages differ, possible due to differences in industry composition of sectors.

wages in manufacturing and construction and utilities has been lower during the period, and even decreased in the last decade of data. The primary sector's relative standard deviation has fluctuated more widely over the period analyzed.

As indicators of wage dispersion, I also calculated the relative wages between pairs of the population 99-to-1, 95-to-5, and 90-to-10 percentiles by sector. These statistics appear in Table 2.10 in the appendix. The ratios of wages for the different levels reported are higher in any given year in services (3) that in manufacturing (2) or construction/utilities (4). This evidence is consistent with that of the relative standard errors, as are the large and volatile ratios for the primary sector.

Other dimensions of sectoral difference, such as input intensity and productivity growth rates (see Acemoglu and Guerrieri 2006) are not included here as they are beyond the scope of the CPS data set.

2.4.2 Estimation strategy

In this section I present estimates on wage differentials between sectors in the economy using baseline model (2.1) on the data sets discussed in the previous section (Table 2.1). The most comprehensive version of these samples includes all individuals who worked full-time (understood as working at least 35 hours per week) in the previous year and earned a positive income. I also estimate wage differentials on a sub-sample of the first data, restricted to male workers only. These two estimates are done for the 1968-2008 time period.

To test the argument of Goux and Maurin (1999) and others that reconstructing the career profile of females might be problematic when assessing the impact of experience in the labor market on wages,[10] I report estimates for all workers and for male workers only. When I compare wage differentials arising from the different samples, the only systematic differences appear in the earlier years of the sample. In the discussion of the results, I argue this difference may arise from the general equilibrium effect of increases in female labor force participation.

As argued in the previous section, Mincer equations should be estimated with wages per hour as the dependent variable; however, these data are only available starting in 1990. Therefore, I estimate regressions with the two alternative dependent variables:

[10] See Cahuc and Zylberberg (2004) for a discussion.

wage/salary income and hourly wage (data sets 1 and 2 in Table 2.1). I present the estimates for all available years in each sample, but restrict myself to the 1990-2008 period when comparing them due to data availability.

Finally, within each of the data sets and dependent variable options, I run regressions over the five different sectoral definitions discussed previously. The first uses the major industrial groups in Table 2.2 with the goal of testing the overall presence of wage differentials. The remaining four regressions aggregate industries into different sectors in the private economy. Table 2.5 shows the minor industry groups that compose sectors in each case. Having different sectoral composition allows me to test the impact of aggregation when studying wage differentials.

Table 2.5: Industry composition of sectors

Sector	Industries⋆
	Option 1
Primary	[A] Agriculture, Forestry, and Fishing, [B] Mining
Manufacturing	[D] Manufacturing
Services	[C] Construction, [E] Transportation, Communication, and Other Utilities, [F] Wholesale and Retail Trade, [G] Finance, Insurance, and Real Estate, [H] Business and Repair Services, [I] Personal services, [J] Entertainment and Recreation Services, [K] Professional and Related Services
	Option 2
Primary	[A] Agriculture, Forestry, and Fishing, [B] Mining
Manufacturing	[C] Construction , [D] Manufacturing, [E3] Utilities and Sanitary Services
Services	[E1] Transportation, [E2] Telecommunication, [F] Wholesale and Retail Trade, [G] Finance, Insurance, and Real Estate, [H] Business and Repair Services, [I] Personal services, [J] Entertainment and Recreation Services, [K] Professional and Related Services
	Option 3
Primary	[A] Agriculture, Forestry, and Fishing
Manufacturing	[B] Mining, [C] Construction , [D] Manufacturing, [E3] Utilities and Sanitary Services
Services	[E1] Transportation, [E2] Telecommunication, [F] Wholesale and Retail Trade, [G] Finance, Insurance, and Real Estate, [H] Business and Repair Services, [I] Personal services, [J] Entertainment and Recreation Services, [K] Professional and Related Services
	Option 4
Primary	[A] Agriculture, Forestry, and Fishing, [B] Mining
Manufacturing	[D] Manufacturing
Cons. and Util.	[C] Construction , [E3] Utilities and Sanitary Services
Services	[E1] Transportation, [E2] Telecommunication, [F] Wholesale and Retail Trade, [G] Finance, Insurance, and Real Estate, [H] Business and Repair Services, [I] Personal services, [J] Entertainment and Recreation Services, [K] Professional and Related Services

⋆: Letters in brackets correspond to Table 2.2.

I estimate industry fixed-effects regressions for each year of data available.[11] Following Angrist and Krueger (1999), I estimate a deviation-from-mean wage equation (2.7):

$$
\begin{aligned}
\log w_{i,t} - \log \overline{w}_t =& \tilde{\mathbf{x}}_{i,t}\mathbf{B}_t + \tilde{\gamma}_{i,t}\mathbf{\Theta}_t + \eta_{i,t} \\
=& \beta_t^0 + \beta_t^f \tilde{D}_{i,t}^f + \beta_t^b \tilde{D}_{i,t}^b + \beta_t^m \tilde{D}_{i,t}^m + \beta_t^u \tilde{D}_{i,t}^u + \sum_{r\in R} \beta_t^r \tilde{D}_{i,t}^r \\
&+ \sum_{e\in E} \beta_t^e \tilde{D}_{i,t}^e + \sum_{a\in A} \beta_t^a \tilde{D}_{i,t}^a + \sum_{s\in S} \theta_t^s \tilde{D}_{i,t}^s + \eta_{i,t}
\end{aligned}
\tag{2.9}
$$

where $\tilde{x} \equiv x - \overline{x}$, the individual deviation from the sample mean $\overline{x}$. The vector $\mathbf{x}$ consists of: a constant, dummies for female workers (D^f), African-American workers (D^b), residence in metropolitan area (D^m), union coverage (D^u, when applicable), nine division-of-residence dummies (D^r), three education level dummies (D^e), and three age group dummies (D^a). Vector $\hat{\gamma}$ includes the industry or sectoral dummies, which vary depending across different models. A detailed description of the explanatory variables appears in Table 2.6.

From the estimated equations, I then construct an indicator of average sectoral wage differences. Recall the definition of $\tilde{x}$, and let $\hat{x}$ be the predicted of variable x. Then, for two sectors $s \neq s'$, the average log-wage difference can be decomposed according to:

$$
\begin{aligned}
\log\left(\frac{\overline{w}_t^s}{\overline{w}_t}\right) - \log\left(\frac{\overline{w}_t^{s'}}{\overline{w}_t}\right) =& \log\left(\frac{\overline{w}_t^s}{\overline{w}_t^{s'}}\right) \\
=& \underbrace{(\overline{\mathbf{x}}_t^s - \overline{\mathbf{x}}_t^{s'})\hat{\mathbf{B}}_t}_{(1)} + \underbrace{\hat{\theta}_t^s - \hat{\theta}_t^{s'}}_{(2)};
\end{aligned}
\tag{2.10}
$$

where the first term is the fraction of (average) wage differentials arising from differences in individual characteristics between sectors, while the second term accounts for "true" sectoral differences. It follows then that "pure" sectoral wage differentials are simply:

$$
\frac{\hat{w}_t^s}{\hat{w}_t^{s'}} = e^{\hat{\theta}_t^s - \hat{\theta}_t^{s'}}. \tag{2.11}
$$

[11] Because I estimate the regressions year-by-year, I am implicitly running a year fixed-effects model as well.

Table 2.6: Explanatory variables

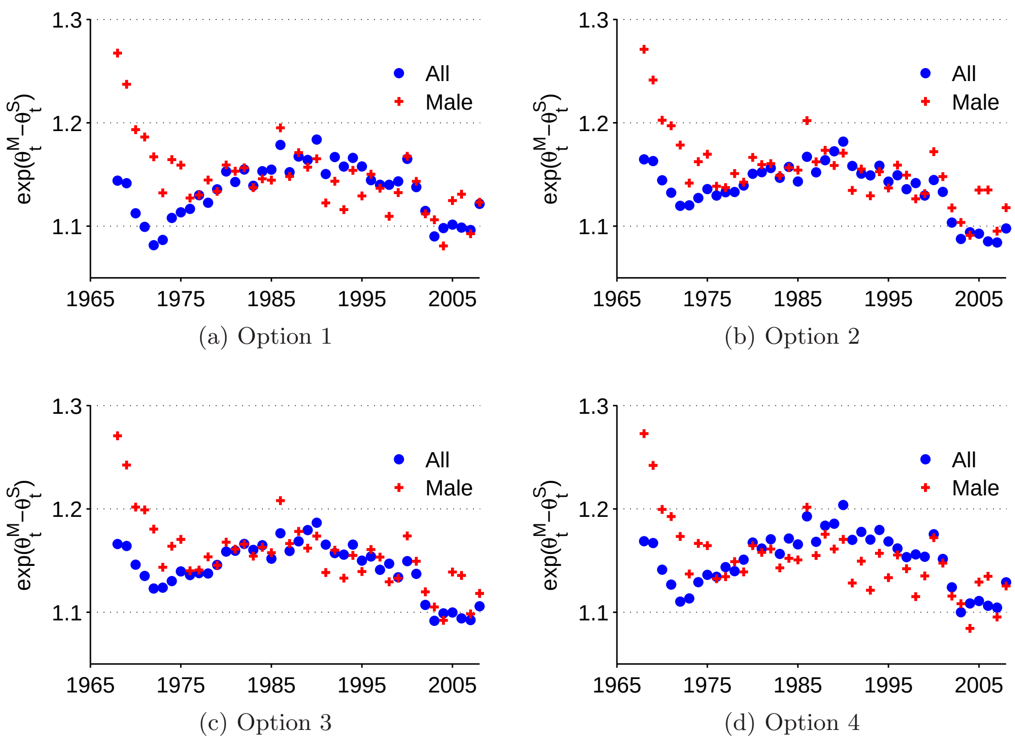
	Dependent variable	
	Hourly wage	Wage/Salary Income
• Availability:	1968-2008	1990-2008
• Individual Characteristics:*	Female, African-American, Metropolitan area	
	Union coverage	–
	Age =	15 − 24 25 − 34 35 − 54 54+
	Education =	less than high school high school some college college +
	Division =	New England Middle Atlantic East North Central West North Central South Atlantic East South Central West South Central Mountain Pacific
	Industry =	15-sector⋆ Option 1 (3 sectors)† Option 2 (3 sectors)† Option 3 (3 sectors)† Option 4 (4 sectors)†

∗: The first category of discrete variables was dropped.
⋆: See Table 2.2. †: See Table 2.5.

2.4.3 Results

Given the estimates of equation (2.9) for the different dependent variables and alternative data sets, I present the output information as follows. The results from the main regression, where I include 14 sectoral dummies, are summarized in Appendix 2.D. Table 2.11 contains the industry dummy parameters, t-statistics and p-values; the adjusted R^2 for the regression, and number of observations for the regressions estimated on all full-time workers who earned a salary or wage income. In all years, a negative gender gap (in favor of males), race gap (in favor of non-African-Americans), and a city gap (in favor of those residing in major metropolitan areas) were present and statistically significant. These results are consistent with that reported in the literature.

For all 41 years of the study period, I tested if the industry dummies were simultaneously equal to zero and rejected this hypothesis with 99% of confidence in every case. Therefore, I can conclude that there are wage differentials beyond those explained by differences in worker characteristics. Moreover, since estimated parameters are added to sector A (Agriculture, Forestry, and Fishing), these results imply that all sectors have higher log-wages than sector A. The sectors with larger dummies (*i.e.*, higher wage premia) are (B) Mining, (E2) Telecommunications, (E3) Utilities and Sanitary Services, and (D1) Manufacture of Durable Goods. The results obtained from the regressions that used hourly wage as dependent variable are consistent with that described above and, therefore, I do not discuss them in detail here (see Table 2.12).



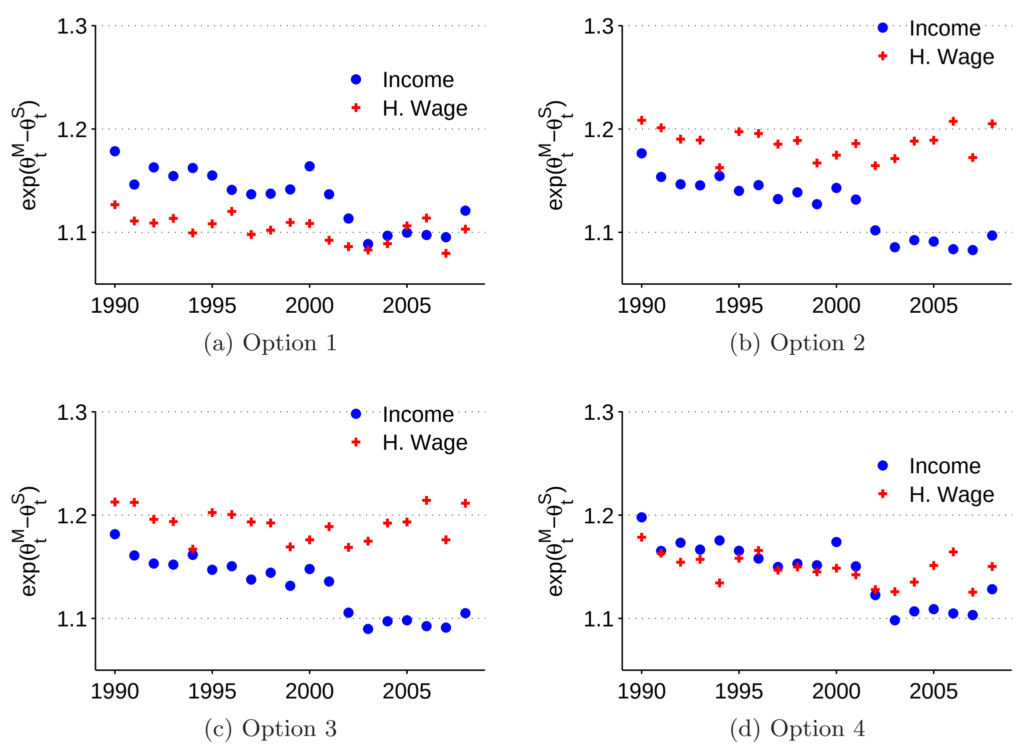
(a) Option 1 (b) Option 2

(c) Option 3 (d) Option 4

Figure 2.2: Wage/salary income differentials: all workers vs. males only

Given the evidence in favor of interindustry wage differentials, I estimate regressions on aggregated sectors. Rather than using the detailed fifteen industrial groups described in Table 2.2, I estimate similar equations grouping industries into major sectors. To test the robustness of my aggregation choice, I analyzed four alternatives, described in Table 2.5. I then plot the expression (2.11) as obtained from the estimated parameters. These parameters are all statistically significant, and their non-linear transformations are statistically different from 1.[12]

Figure 2.2 depicts wage differentials between manufacturing and services arising from regressions estimated on wage/salary income as the dependent variable. Regardless of the sectoral aggregation option used, an overall decreasing trend is evident for male workers; this trend is less steep after the mid-1970s. Moreover, when all workers are considered, there is a decrease in the wage gap until the beginning of the 1970s, followed by roughly a decade of wage gap increase (until the mid-1980s), before decreasing again.



(a) Option 1 (b) Option 2

(c) Option 3 (d) Option 4

Figure 2.3: Hourly wage differentials: all workers vs. males only

[12]Due to the space constraints, as with other estimates, output data are not included; they available from the author upon request.

The comparison of wage differentials between estimates on wage/salary income and hourly wages is depicted in Figure 2.3. A decreasing trend during the 1990-2008 period is more evident for estimates on wage/salary income ("Income" in the graphs) than for estimates on hourly wage across the first three aggregation options. The fourth option yields similar estimates between the two dependent variables in terms of levels and trend.

Figure 2.4 shows the wage differentials between construction/utilities and services as given by aggregation option 4. When wage/salary income is used to estimate this differential, there is a somewhat decreasing trend in the gap between these two sectors (left panel). However, the wage differences for male workers are larger than those for the entire sample. The right panel shows wage differentials for hourly wages compared to wage/salary income. Neither alternative yields a clear trend for the 1990-2008 period; the gap generated in the hourly wage regressions is larger than the one calculated from wage/salary income.

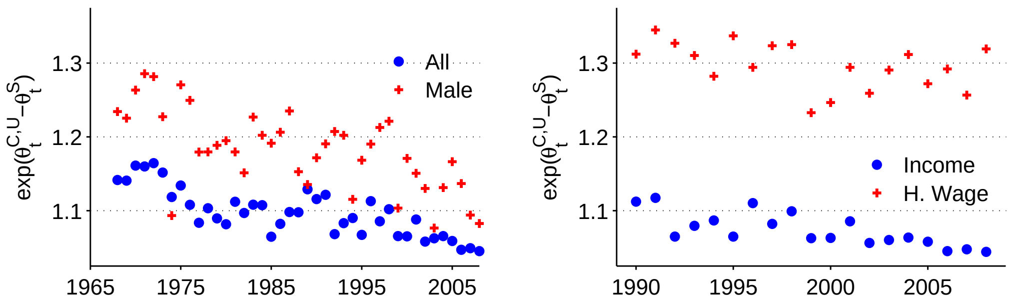
Finally, it should be noted that other regularities, such as male-female and black-non-black differentials, are also prevalent in all estimations.[13] Moreover, the estimates on the hourly wage, which control for union coverage, yield a statistically significant union wage premium. This premium went from around 35 percent in the early 1990s, to close to 25 percent in the late 2000s, all other things equal. The presence of this premium is consistent with that reported in Kahn (1998).[14]

2.5 Concluding remarks

The purpose of this paper is to present a concise review of the relevant literature on group wage dispersion, and to estimate interindustry and intersectoral wage differentials. To achieve the first goal, I present empirical evidence of relevant papers in the literature. Then, I discuss the evolution of econometric techniques developed for this purpose over the last 60 years. Whenever appropriate employer-employee match data panels are available, the optimal econometric technique is to estimate an individual, firm, and employer-employee match fixed effects model. The evidence arising from such

[13] These results were not reported due to space constraints, but are available upon request.

[14] When employing wage/salary income, the union premium went from around 20 to 10 percent in the same period of time.



(a) All vs. Male (b) Wages vs. Income

Figure 2.4: Differentials: construction, utilities vs. services

estimations suggests that unobserved characteristics (from individuals, firms, and their interaction) largely explain wage differentials in general, and interindustry differences, in particular.

Motivated by the discussion on evidence and methodology, I then estimate wage differentials for the United States employing CPS data. This data set, provided by the IPUMS-CPS project (King et al. 2008), has the advantages of a long time span availability (1962 to 2008, in the best case) and the comparability of variables across time. These characteristics allow me to compare sectoral wage differentials over a long period of time: 1968 to 2008. Since the data set is not a linked panel, I cannot track workers or firms over time; this keeps me from testing the hypothesis on the presence of individual and firm unobserved characteristics using fixed and random effects models.

To mitigate this limitation, I test a number of specifications and subsets of the data as a robustness check of my estimates. From a regression with fairly detailed industries (*i.e.*, one with 15 industry dummies), I can reject with high statistical confidence (99%) the hypothesis that there are no sectoral wage differentials beyond those caused by differences in individual characteristics. I assume that there are industry fixed effects and avoid calculating interaction terms (*i.e.*, allowing the rates of return of different characteristics to differ across sectors) due to computational restrictions and little predictive power or such effects.

Moreover, I estimate four versions of more aggregated sectoral groups to test the hypothesis of wage differences in favor of manufacturing or construction and utilities, compared to services. I find – robustly across four sectoral aggregations – that workers in the manufacturing sector are favored with higher wages than those in manufacturing. This wage gap is statistically significant in all years estimated. More importantly, the wage gap is not constant. As discussed in the results subsection, the wage gap estimated for all workers grew from the early 1970s to the late 1980s and later decreased. This is consistent with gains of wages by workers during this period of time (Katz and Autor 1999). The equivalent gap estimated for male workers only, monotonically decreases in the period studied. Understanding the reason why these estimates follow different trends is beyond the scope of this paper. Yet it is possible that problems with the reconstruction of female workers' carrier profiles, which has been identified in the literature, and the general equilibrium effect of the increase in female participation in the economy are behind this difference.

Further empirical work remains to be done. Estimates on panel data and, more ideally, employer-employee match data sets (such as the U.S. Census Bureau's Longitudinal Employer-Household Dynamics – LEHD – database) will allow me to test the robustness of this findings, when controlling for individual, firm, and potentially employer-employee match effects.

2.A IPUMS-CPS variable description

Table 2.7 indicates the availability and universe of the original variables in the CPS.

Table 2.7: Variable availability and universe

AGE: Age	CLASSWORK: Class of worker
1968-2008: All persons.	1968-1987: Persons age 14+ who ever worked. 1988-2008: Persons age 15+ who ever worked.
EARNWT: Earnings weight	**EDUCREC: Educational attainment recode**
1990-2001: Persons in 2 (out of 8) rotation groups.	1968-1979: Persons age 14+. 1978-2008: Persons age 15+.
EMPSTAT: Employment status	**FULLPART: Worked full or part time last year**
1968-1987: Persons age 14+. 1988-2008: Persons age 15+.	1968-1979: Civilians 14+ who worked at least 14 weeks during the previous year. 1980-1989: Civilians 15+ who worked at least 14 weeks during the previous year. 1990-2008: Persons 15+ who worked at least 14 weeks during the previous year.
HOURWAGE: Hourly wage	**INCWAGE: Wage and salary income**
1990-2001: Civilians 15+ currently employed as wage/salary workers and in 2 (out of 8) rotation groups. Excludes self-employed persons. 2002-2008: Civilians 15+ currently employed as wage/salary workers and were asked the "earner study" questions. Excludes self-employed persons.	1968-1979: Persons age 14+. 1980-2008: Persons age 15+.
IND1950: Industry, 1950 basis*	**METAREA: Metropolitan central city status**
1968-1979: Civilians age 14+ who: were currently employed; or had previously worked and were looking for work; or were not currently in the labor force but had worked in the preceding 5 years and were in 2 (out of 8) rotation groups. 1980-2008: Civilians age 15+ who: were currently employed; or had previously worked and were looking for work; or were not currently in the labor force but had worked in the preceding 5 years and were in 2 (out of 8) rotation groups.	1968-2008: All households and group quarters.
PAIDHOUR: Paid by the hour	**PERWT: Person weight**
1990-2001: Civilians 15+ currently employed as wage/salary workers and in 2 (out of 8) rotation groups. Excludes self-employed persons. 2002-2008: Civilians 15+ currently employed as wage/salary workers and were asked the ”earner study” questions. Excludes self-employed persons.	1968-2008: All persons.
RACE: Race	**REGION: Region and division**
1968-2008: All persons.	1968-2008: All households and group quarters.
SEX: Sex	**UNION: Union membership**
1968-2008: All persons.	1990-2001: Civilians 15+ currently employed as wage/salary workers and in 2 (out of 8) rotation groups. Excludes self-employed persons. 2002-2008: Civilians 15+ currently employed as wage/salary workers and were asked the "earner study" questions. Excludes self-employed persons.

⋆ : Unharmonized variable IND is available starting in the 1962-1967 period for civilians age 14+.
Variable universes for pre-1968 samples do not include persons under age 14.
For complete information on variable universe, see IPUMS-CPS, King et al. (2008).

2.B Major and minor industries

Table 2.8 details the major industrial groups (denoted with letters) and minor industries that compose them, for the 1968-2008 period variable IND1950.

Table 2.8: Major and minor industries

	IND1950 industries (1968-2008)
[A]	**Agriculture, Forestry, and Fishing:**
	(105) Agriculture, (116) Forestry, (126) Fisheries
[B]	**Mining:**
	(206) Metal mining, (216) Coal mining, (226) Crude petroleum and natural gas extraction, (236) Nonmetallic mining and quarrying, except fuel
[C]	**Construction:**
	(246) Construction
[D]	**Manufacturing:**
[D1]	**Durable Goods:**
	(306) Logging, (307) Sawmills, planing mills, and millwork, (308) Misc wood products, (309) Furniture and fixtures, (316) Glass and glass products, (317) Cement, concrete, gypsum and plaster products, (318) Structural clay products, (319) Pottery and related products, (326) Miscellaneous nonmetallic mineral and stone products, (336) Blast furnaces, steel works, and rolling mills, (337) Other primary iron and steel industries, (338) Primary nonferrous industries, (346) Fabricated steel products, (347) Fabricated nonferrous metal products, (348) Not specified metal industries, (356) Agricultural machinery and tractors, (357) Office and store machines and devices, (358) Miscellaneous machinery, (367) Electrical machinery, equipment, and supplies, (376) Motor vehicles and motor vehicle equipment, (377) Aircraft and parts, (378) Ship and boat building and repairing, (379) Railroad and miscellaneous transportation equipment, (386) Professional equipment and supplies, (387) Photographic equipment and supplies, (388) Watches, clocks, and clockwork-operated devices, (399) Miscellaneous manufacturing industries
[D2]	**Nondurable Goods:**
	(406) Meat products, (407) Dairy products, (408) Canning and preserving fruits, vegetables, and seafoods, (409) Grain-mill products, (416) Bakery products, (417) Confectionery and related products, (418) Beverage industries, (419) Miscellaneous food preparations and kindred products, (426) Not specified food industries, (429) Tobacco manufactures, (436) Knitting mills, (437) Dyeing and finishing textiles, except knit goods, (438) Carpets, rugs, and other floor coverings, (439) Yarn, thread, and fabric mills, (446) Miscellaneous textile mill products, (448) Apparel and accessories, (449) Miscellaneous fabricated textile products, (456) Pulp, paper, and paperboard mills, (457) Paperboard containers and boxes, (458) Miscellaneous paper and pulp products, (459) Printing, publishing, and allied industries, (466) Synthetic fibers, (467) Drugs and medicines, (468) Paints, varnishes, and related products, (469) Miscellaneous chemicals and allied products, (476) Petroleum refining, (477) Miscellaneous petroleum and coal products, (478) Rubber products, (487) Leather: tanned, curried, and finished, (488) Footwear, except rubber, (489) Leather products, except footwear, (499) Not specified manufacturing industries
[E]	**Transportation, Communication, and Other Utilities:**
[E1]	**Transportation:**
	(506) Railroads and railway express service, (516) Street railways and bus lines, (526) Trucking service, (527) Warehousing and storage, (536) Taxicab service, (546) Water transportation, (556) Air transportation, (567) Petroleum and gasoline pipe lines, (568) Services incidental to transportation
[E2]	**Telecommunications:**
	(578) Telephone, (579) Telegraph
[E3]	**Utilities and Sanitary Services:**
	(586) Electric light and power, (587) Gas and steam supply systems, (588) Electric-gas utilities, (596) Water supply, (597) Sanitary services, (598) Other and not specified utilities

Continued on next page

IND1950 industries (1968-2008)

[F]	**Wholesale and Retail Trade:**
[F1]	**Wholesale Trade:** (606) Motor vehicles and equipment, (607) Drugs, chemicals, and allied products, (608) Dry goods apparel, (609) Food and related products, (616) Electrical goods, hardware, and plumbing equipment, (617) Machinery, equipment, and supplies, (618) Petroleum products, (619) Farm products–raw materials, (626) Miscellaneous wholesale trade, (627) Not specified wholesale trade
[F2]	**Retail Trade:** (636) Food stores, except dairy products, (637) Dairy products stores and milk retailing, (646) General merchandize stores, (647) Five and ten cent stores, (656) Apparel and accessories stores, except shoe, (657) Shoe stores, (658) Furniture and house furnishing stores, (659) Household appliance and radio stores, (667) Motor vehicles and accessories retailing, (668) Gasoline service stations, (669) Drug stores, (679) Eating and drinking places, (686) Hardware and farm implement stores, (687) Lumber and building material retailing, (688) Liquor stores, (689) Retail florists, (696) Jewelry stores, (697) Fuel and ice retailing, (698) Miscellaneous retail stores, (699) Not specified retail trade
[G]	**Finance, Insurance, and Real Estate:**
	(716) Banking and credit agencies, (726) Security and commodity brokerage and investment companies, (736) Insurance, (746) Real estate
[H]	**Business and Repair Services:**
	(806) Advertising, (807) Accounting, auditing, and bookkeeping services, (808) Miscellaneous business services, (816) Auto repair services and garages, (817) Miscellaneous repair services
[I]	**Personal services:**
	(826) Private households, (836) Hotels and lodging places, (846) Laundering, cleaning, and dyeing services, (847) Dressmaking shops, (848) Shoe repair shops, (849) Miscellaneous personal services
[J]	**Entertainment and Recreation Services:**
	(856) Radio broadcasting and television, (857) Theaters and motion pictures, (858) Bowling alleys, and billiard and pool parlors, (859) Miscellaneous entertainment and recreation services
[K]	**Professional and Related Services:**
	(868) Medical and other health services, except hospitals, (869) Hospitals, (879) Legal services, (888) Educational services, (896) Welfare and religious services, (897) Nonprofit membership organizations, (898) Engineering and architectural services, (899) Miscellaneous professional and related services
[L]	**Public Administration:**
	(906) Postal service, (916) Federal public administration, (926) State public administration, (936) Local public administration

Industrial categories in CPS use the Census Bureau 1950 industrial classification system.

List excludes: (0) Not in universe, (997) Unknown, and (998) Industry not reported.

Source: IPUMS-CPS, King et al. (2008).

2.C Descriptive statistics

This appendix contains the detailed statistics summarized in Table 2.3 for the 41 years of data between 1968 and 2008. The data are organized into four sectors: (1) Primary, (2) Manufacturing, (3) Services, and (4) Construction and Utilities, as described in Tables 2.5 and 2.8.

Table 2.9 presents the fraction of workers by sector and the sample size for each year, along with the average wage and salary income in current dollars by sector and year, the fraction of female workers, and the average age by industry and year, the fraction of African-American workers, and the fraction of the workforce with a college or higher degree.

Table 2.9: Descriptive statistics

Year	**(1)**	**(2)**	**(3)**	**(4)**	**All**	**(1)**	**(2)**	**(3)**	**(4)**	**All**
	Fraction of Population					**Wage/Salary Income $**				
1968	2.81	41.16	47.94	8.09	35,395	4,761	6,453	5,629	6,869	6,044
1969	2.74	41.13	47.95	8.18	35,461	5,022	6,945	6,120	7,440	6,537
1970	2.46	41.00	48.05	8.48	34,109	5,750	7,620	6,808	8,399	7,250
1971	2.61	38.56	50.27	8.55	34,085	6,170	7,884	7,238	8,886	7,600
1972	2.70	38.09	50.29	8.93	32,526	6,605	8,173	7,608	9,184	7,937
1973	2.80	37.28	50.96	8.96	32,444	7,367	8,803	8,162	9,866	8,531
1974	2.98	37.30	50.97	8.76	32,294	7,521	9,559	8,693	10,390	9,130
1975	2.91	36.76	51.84	8.48	31,485	8,620	10,215	9,197	10,974	9,705
1976	3.17	35.31	53.37	8.15	32,925	8,915	10,798	9,836	11,599	10,290
1977	3.11	35.47	53.37	8.05	39,410	9,853	11,739	10,465	12,211	11,038
1978	3.07	34.79	53.84	8.31	39,524	10,266	12,555	11,357	13,261	11,899
1979	3.06	34.91	53.59	8.45	40,483	11,928	13,693	12,224	14,160	12,891
1980	3.10	34.53	53.69	8.68	48,256	12,994	15,134	13,352	15,337	14,129
1981	3.36	33.49	54.82	8.34	48,277	14,320	16,299	14,488	16,712	15,274
1982	3.53	32.33	56.02	8.13	43,157	16,882	17,805	16,062	18,023	16,814
1983	3.65	31.11	57.03	8.21	41,874	18,053	19,000	17,114	19,275	17,912
1984	3.23	30.35	57.52	8.90	41,710	17,541	19,995	17,929	19,931	18,721
1985	3.12	30.05	58.05	8.79	43,914	19,260	21,227	19,104	20,517	19,871
1986	3.20	28.91	59.03	8.86	43,702	19,500	22,715	20,024	21,562	20,922
1987	3.02	28.11	60.16	8.71	43,670	18,591	23,631	21,037	22,646	21,832
1988	3.00	27.69	60.59	8.72	45,282	18,589	24,321	21,755	23,466	22,520
1989	3.05	27.41	60.75	8.79	42,437	19,363	25,357	22,901	24,914	23,643
1990	2.95	26.26	61.75	9.04	46,426	19,656	26,677	23,889	25,928	24,680
1991	3.10	25.97	62.16	8.77	46,106	20,359	27,186	24,607	26,322	25,296
1992	2.95	25.18	63.49	8.39	45,023	21,390	27,949	25,422	26,345	26,017
1993	2.92	24.58	64.40	8.10	44,022	21,682	29,186	26,506	27,677	27,119
1994	2.88	24.38	64.91	7.83	42,638	23,550	30,025	27,206	27,960	27,847
1995	2.91	24.10	64.61	8.37	43,632	23,882	31,245	28,277	28,487	28,882
1996	3.07	23.31	65.16	8.45	39,341	24,649	34,179	31,346	32,009	31,857
1997	2.99	23.26	65.15	8.59	40,481	26,460	34,929	33,202	33,300	33,411
1998	2.65	22.65	66.06	8.63	40,361	25,947	36,533	34,734	34,704	34,906
1999	2.53	22.13	66.71	8.63	41,251	27,634	38,293	36,284	35,088	36,407
2000	2.63	21.77	66.89	8.72	42,345	27,302	39,553	36,786	35,836	37,056
2001	2.54	20.66	67.98	8.81	41,379	28,616	42,931	40,301	38,079	40,352
2002	2.48	19.43	68.81	9.27	66,856	30,626	43,959	42,528	39,509	42,230
2003	2.65	17.91	70.01	9.43	65,060	31,475	43,603	43,629	39,795	42,940
2004	2.68	18.02	69.74	9.55	63,581	31,832	45,417	43,950	40,830	43,591
2005	2.72	17.29	70.16	9.83	59,905	36,764	47,407	45,843	40,918	45,382
2006	2.87	17.19	69.94	10.00	60,302	35,868	48,379	47,314	41,412	46,578
2007	2.89	16.73	70.11	10.27	60,533	37,820	50,218	49,488	42,816	48,588
2008	2.89	16.08	71.09	9.94	60,521	37,721	53,233	49,493	44,485	49,257

Continued on next page

Year	(1)	(2)	(3)	(4)	All	(1)	(2)	(3)	(4)	All
	Fraction of Female Workers (%)					**Average Age**				
1968	7.95	26.74	41.52	5.38	31.57	40.09	39.85	39.68	39.27	39.73
1969	8.34	26.13	42.37	5.17	31.71	41.28	39.69	39.79	39.37	39.75
1970	9.27	26.26	42.23	5.66	31.77	39.78	39.57	39.76	39.62	39.67
1971	10.09	26.40	41.35	5.60	31.71	39.61	39.74	39.32	39.18	39.48
1972	10.18	26.66	40.99	5.19	31.50	39.33	39.73	39.08	38.15	39.25
1973	10.49	26.75	41.39	5.32	31.83	39.30	39.17	38.42	37.76	38.66
1974	9.80	26.90	42.23	5.98	32.37	38.09	38.80	37.98	37.08	38.21
1975	8.79	26.98	42.25	5.39	32.54	37.13	38.95	37.67	37.23	38.09
1976	9.45	28.06	42.74	6.29	33.53	36.65	39.24	37.23	37.46	37.94
1977	9.52	28.37	43.04	7.45	33.93	36.30	38.81	36.94	36.99	37.59
1978	13.50	28.97	43.50	7.03	34.50	36.05	38.32	36.81	36.64	37.29
1979	12.41	29.50	44.79	8.22	35.37	36.09	38.08	36.56	36.49	37.07
1980	13.00	30.03	45.57	7.67	35.91	35.22	38.05	36.53	36.08	36.97
1981	13.44	29.90	46.12	8.22	36.43	35.39	38.04	36.53	36.31	36.98
1982	14.37	30.76	45.64	9.37	36.78	34.90	38.26	36.54	36.25	37.02
1983	13.70	30.54	46.61	8.32	37.27	35.30	38.63	36.59	36.27	37.15
1984	15.68	31.89	46.60	9.51	37.83	35.74	38.60	36.64	36.36	37.18
1985	14.34	31.87	47.28	9.96	38.34	35.37	38.31	36.69	36.09	37.08
1986	15.52	30.65	47.54	9.96	38.30	35.27	38.54	36.55	35.99	37.03
1987	15.40	31.46	47.72	9.82	38.87	35.93	38.71	36.52	36.50	37.12
1988	16.69	31.27	48.09	9.10	39.09	36.64	38.26	36.71	36.35	37.11
1989	17.10	31.52	48.14	9.60	39.25	36.79	38.59	36.93	36.51	37.34
1990	15.83	31.44	48.26	9.97	39.42	36.44	38.56	37.15	36.51	37.44
1991	17.51	31.72	48.10	10.29	39.58	36.74	38.85	37.39	36.81	37.70
1992	16.13	31.37	48.59	10.19	40.08	37.45	39.18	37.61	36.93	37.94
1993	17.29	30.63	48.39	10.19	40.02	37.58	39.29	38.01	37.47	38.27
1994	15.32	29.89	48.08	10.08	39.72	37.50	39.28	37.90	37.74	38.21
1995	14.66	30.59	48.34	9.18	39.80	37.98	39.25	37.94	37.71	38.24
1996	18.06	30.79	48.15	9.89	39.94	39.27	39.51	38.38	38.09	38.64
1997	17.31	31.11	48.42	9.41	40.11	39.63	39.73	38.71	38.41	38.95
1998	17.67	30.79	48.62	9.66	40.40	38.18	39.92	38.76	38.44	38.98
1999	17.39	30.17	48.86	9.57	40.54	38.43	40.30	38.85	37.96	39.08
2000	18.80	32.03	48.57	9.51	40.78	38.82	40.54	39.05	38.43	39.32
2001	19.83	31.27	49.17	9.95	41.27	38.99	41.13	39.05	38.49	39.42
2002	17.46	29.15	48.99	9.63	40.70	38.31	41.52	39.57	38.49	39.82
2003	19.96	29.55	48.59	9.55	40.74	38.92	41.77	40.02	38.68	40.18
2004	18.17	30.03	48.84	9.46	40.86	39.48	42.14	40.21	38.59	40.39
2005	17.46	29.56	48.37	9.24	40.43	39.28	42.15	40.68	38.49	40.68
2006	17.49	29.51	48.43	9.16	40.37	39.18	42.42	40.71	38.74	40.76
2007	18.10	29.85	48.29	9.34	40.33	39.85	42.73	40.77	39.13	40.90
2008	16.73	28.75	48.83	9.59	40.77	40.10	42.91	40.99	39.95	41.17
	Black Workers (%)					**College Graduates (%)**				
1968	14.26	8.75	10.53	9.76	9.84	4.19	7.83	10.82	4.16	8.86
1969	12.08	9.66	9.86	9.40	9.80	4.27	7.63	11.35	4.02	9.03
1970	11.45	9.58	9.94	8.43	9.70	6.52	8.32	11.97	4.40	9.70
1971	11.31	9.67	9.47	9.48	9.60	5.52	8.51	12.97	4.75	10.35
1972	10.09	9.17	9.47	8.00	9.24	7.83	8.24	13.69	4.75	10.66
1973	8.59	9.42	9.37	7.57	9.20	7.37	8.60	14.11	5.66	11.11
1974	7.89	10.37	9.27	8.23	9.55	7.68	8.89	15.25	5.74	11.82
1975	6.79	9.74	8.95	9.76	9.25	7.64	9.79	16.63	6.37	12.98
1976	7.02	9.85	8.92	6.45	8.99	8.61	10.19	17.67	7.54	13.92
1977	9.37	10.01	9.05	6.74	9.21	9.73	10.75	17.88	8.01	14.30
1978	8.09	10.04	9.07	6.95	9.20	9.52	11.10	17.81	7.95	14.40
1979	8.95	10.04	9.07	7.55	9.28	10.56	11.62	19.01	8.10	15.25
1980	7.54	10.09	9.15	8.16	9.34	10.74	11.97	19.69	9.06	15.82
1981	7.79	9.64	9.29	7.57	9.22	11.55	12.66	20.30	8.87	16.49

Continued on next page

Year	**(1)**	**(2)**	**(3)**	**(4)**	**All**	**(1)**	**(2)**	**(3)**	**(4)**	**All**
1982	8.06	9.65	9.38	8.16	9.32	13.99	13.15	21.79	8.66	17.65
1983	7.62	10.08	9.15	6.51	9.17	14.77	15.05	23.81	9.62	19.59
1984	7.30	9.90	9.26	5.98	9.10	14.31	15.77	23.85	9.90	19.85
1985	5.50	9.95	9.58	6.62	9.31	17.49	15.84	23.69	10.45	19.98
1986	6.33	9.91	10.01	6.93	9.59	15.92	16.73	24.24	10.71	20.60
1987	4.78	10.69	9.90	7.66	9.77	12.40	17.89	24.40	10.21	20.97
1988	5.94	10.15	10.18	7.89	9.84	15.06	18.07	24.83	10.41	21.41
1989	6.80	10.32	10.20	7.73	9.91	14.95	17.28	25.89	11.69	21.95
1990	6.21	10.19	10.91	7.27	10.25	14.09	17.91	26.29	12.29	22.46
1991	5.59	10.63	10.15	7.79	9.93	12.96	18.36	26.50	11.14	22.62
1992	4.65	10.50	10.28	7.40	9.93	13.14	18.05	26.23	11.14	22.52
1993	5.89	10.06	10.43	7.65	9.98	13.80	18.99	26.90	11.73	23.34
1994	5.60	9.48	10.67	7.78	10.00	14.47	19.28	27.64	11.57	23.96
1995	4.47	10.46	10.84	6.81	10.23	17.24	19.64	28.10	11.67	24.37
1996	4.74	11.03	11.08	6.81	10.51	12.74	19.51	28.69	12.51	24.69
1997	3.14	11.02	11.14	7.65	10.57	12.94	20.40	28.59	11.08	24.71
1998	4.25	10.92	11.74	7.72	11.01	12.79	20.26	29.03	11.35	25.09
1999	4.58	10.17	11.97	6.83	10.94	13.58	20.62	29.33	12.18	25.53
2000	4.04	10.11	12.63	7.33	11.39	12.71	21.19	30.09	11.36	26.06
2001	4.53	10.68	13.18	7.04	11.90	15.37	21.25	30.36	10.97	26.39
2002	5.55	9.82	11.98	6.91	10.93	13.99	22.47	31.32	11.51	27.34
2003	4.45	9.28	11.84	6.21	10.65	12.80	22.75	31.83	12.21	27.85
2004	4.13	9.48	12.08	5.69	10.78	13.78	24.62	31.74	12.05	28.10
2005	3.50	10.44	11.69	5.76	10.67	15.78	25.33	32.57	11.28	28.77
2006	4.95	9.65	11.57	6.04	10.49	12.93	25.39	32.97	11.26	28.92
2007	3.94	8.95	12.11	6.15	10.73	14.78	25.35	34.02	12.40	29.79
2008	3.97	9.31	11.87	5.27	10.57	12.13	27.49	34.62	12.92	30.67

Source: Author's calculations, IPUMS-CPS, King et al. (2008).

Table 2.10 reports the relative wages between different percentile pairs: 99% to 1%, 95% to 5%, and 90% to 10%.

Table 2.10: Relative wages

	All	(1)	(2)	(3)	(4)	All	(1)	(2)	(3)	(4)
			1968					1979		
99/1	64.1	127.3	40.0	86.3	36.0	49.5	52.7	30.0	50.0	37.5
95/5	12.9	21.2	7.6	16.1	8.0	10.7	14.7	8.6	13.0	10.0
90/10	5.4	11.3	4.2	6.9	4.1	6.0	8.0	4.8	6.3	5.6
			1969					1980		
99/1	56.5	112.9	32.7	83.3	35.0	43.5	50.6	31.3	50.0	43.9
95/5	11.7	18.3	7.0	14.2	7.8	10.7	16.2	7.9	11.9	10.1
90/10	5.6	9.3	4.0	6.9	4.4	5.7	8.4	4.7	6.3	5.2
			1970					1981		
99/1	40.9	62.2	24.8	51.4	27.2	38.5	100.0	25.0	46.9	31.3
95/5	10.0	16.1	7.2	12.5	7.2	10.6	17.7	8.2	11.7	9.6
90/10	5.2	8.1	4.2	6.0	4.4	5.6	8.2	4.8	6.1	5.3
			1971					1982		
99/1	42.2	95.3	25.1	55.9	30.0	43.3	75.0	26.6	56.0	40.4
95/5	9.7	14.6	7.4	11.7	7.7	11.0	17.0	8.0	12.9	9.7
90/10	5.2	7.5	4.2	6.2	4.8	5.8	9.0	4.7	6.1	6.1

Continued on next page

	All	(1)	(2)	(3)	(4)	All	(1)	(2)	(3)	(4)
			1972					1983		
99/1	44.2	71.6	28.8	57.7	27.8	50.0	115.4	30.0	53.6	37.5
95/5	10.5	17.3	7.8	12.6	7.8	11.1	18.3	8.4	12.0	10.5
90/10	5.4	8.3	4.6	6.4	4.6	5.9	9.5	5.0	6.3	5.8
			1973					1984		
99/1	46.3	95.0	29.9	59.0	33.2	46.9	71.4	31.8	57.7	34.7
95/5	10.9	17.0	8.3	12.8	9.2	11.0	17.2	8.8	12.2	10.8
90/10	5.6	7.5	4.7	6.5	5.2	5.8	8.9	5.1	6.2	6.0
			1974					1985		
99/1	46.9	52.0	30.0	58.7	39.8	53.3	97.4	37.5	63.8	45.9
95/5	11.0	13.6	8.7	13.2	8.7	11.7	20.0	9.1	12.9	11.4
90/10	5.6	6.7	4.7	6.5	4.9	6.2	10.4	5.3	6.4	6.3
			1975					1986		
99/1	50.0	75.0	32.7	68.7	34.9	54.7	86.0	31.2	64.3	47.3
95/5	10.5	12.7	8.2	12.2	8.9	12.2	16.3	9.3	12.5	12.0
90/10	5.8	6.6	4.6	6.4	4.9	6.3	8.4	5.1	6.3	6.0
			1976					1987		
99/1	43.3	87.5	26.0	57.5	34.5	55.9	76.0	37.4	66.7	36.0
95/5	11.3	15.1	7.9	12.8	9.2	11.8	19.6	9.1	13.0	9.9
90/10	5.9	8.4	4.6	6.2	5.1	6.2	10.0	5.3	6.7	5.7
			1977					1988		
99/1	40.0	62.6	25.7	60.0	36.0	54.4	250.0	30.8	63.8	52.0
95/5	11.4	14.7	8.3	12.4	10.9	11.6	24.3	8.8	13.1	10.2
90/10	5.8	7.5	4.8	6.5	5.3	6.2	10.5	5.5	6.6	6.1
			1978					1989		
99/1	45.6	100.0	26.7	50.0	36.4	55.6	180.0	30.3	64.2	37.5
95/5	10.5	19.1	8.7	12.3	8.9	11.6	22.1	9.2	13.3	8.6
90/10	5.9	9.5	4.9	6.4	5.1	6.4	9.9	5.2	6.4	5.6
			1990					2000		
99/1	55.6	308.6	30.9	62.0	46.5	76.4	83.3	49.9	90.7	57.7
95/5	12.0	25.5	9.3	13.0	11.6	12.3	14.6	8.9	13.9	10.8
90/10	6.3	13.9	5.3	6.4	5.9	6.4	8.0	5.1	7.0	5.9
			1991					2001		
99/1	50.0	246.8	36.8	55.6	35.4	111.7	106.9	65.7	111.7	37.5
95/5	12.0	27.0	9.1	12.0	10.8	12.3	14.4	9.1	12.5	8.9
90/10	6.1	11.6	5.4	6.4	6.0	6.0	8.1	5.2	6.7	5.2
			1992					2002		
99/1	50.0	228.3	32.9	53.4	66.7	93.2	229.1	55.7	101.1	106.9
95/5	12.1	21.7	9.0	13.0	11.4	11.1	15.0	8.3	12.3	10.0
90/10	6.3	9.7	5.0	6.2	6.1	6.3	8.6	5.1	6.5	5.8
			1993					2003		
99/1	50.0	222.2	33.3	50.0	47.6	120.3	87.1	35.0	130.3	40.0
95/5	12.1	20.0	9.6	13.1	11.1	11.3	13.3	9.1	13.3	8.9
90/10	6.3	9.7	5.3	6.3	6.3	6.5	7.4	5.5	6.7	5.4
			1994					2004		
99/1	62.5	125.0	35.7	66.7	50.0	110.1	136.4	35.4	130.3	54.3

Continued on next page

	All	(1)	(2)	(3)	(4)	All	(1)	(2)	(3)	(4)
95/5	13.3	23.7	9.9	14.0	11.0	11.7	17.0	9.5	12.2	9.3
90/10	6.6	11.1	5.5	6.5	6.2	6.4	7.5	5.7	6.7	5.4
			1995					2005		
99/1	43.2	166.7	33.3	43.5	40.0	141.0	248.7	40.0	141.0	40.0
95/5	12.5	22.4	10.0	13.8	10.8	11.8	16.0	9.2	12.8	9.9
90/10	6.3	10.4	5.9	6.7	6.0	6.4	7.3	5.9	6.8	5.5
			1996					2006		
99/1	75.0	200.0	48.8	134.3	46.9	102.5	100.0	38.0	105.9	56.5
95/5	12.5	21.7	10.2	12.9	10.0	11.5	15.2	9.3	12.3	10.2
90/10	6.4	9.2	5.8	6.4	5.6	6.4	8.1	5.8	6.8	5.6
			1997					2007		
99/1	145.0	120.0	38.9	155.6	55.0	109.4	49.1	36.4	125.0	41.3
95/5	12.7	16.4	9.5	13.3	10.7	12.0	12.8	10.0	12.5	10.0
90/10	6.1	9.1	5.4	6.6	6.0	6.4	7.4	6.1	6.7	5.4
			1998					2008		
99/1	122.6	150.0	38.7	126.5	46.7	105.0	125.0	61.0	105.0	34.0
95/5	11.9	22.4	9.1	13.1	9.4	12.0	15.8	9.6	12.5	10.0
90/10	6.2	9.1	5.4	6.2	5.5	6.0	7.5	5.9	6.2	5.4
			1999							
99/1	102.2	100.0	37.0	110.7	45.1					
95/5	12.0	17.5	8.5	12.9	10.7					
99/10	6.3	8.7	5.3	6.5	5.7					

Source: Author's calculations, IPUMS-CPS, King et al. (2008).

2.D Empirical estimates: 15-sector regression tables

Table 2.11: Wage/salary estimates

	Year								
	1968	1969	1970	1971	1972	1973	1974	1975	1976
[B]	0.77	0.828	0.775	0.753	0.775	0.738	0.615	0.665	0.798
	(0.04)**	(0.04)**	(0.039)**	(0.039)**	(0.04)**	(0.04)**	(0.04)**	(0.041)**	(0.038)**
[C]	0.645	0.704	0.666	0.608	0.646	0.567	0.459	0.497	0.519
	(0.027)**	(0.028)**	(0.027)**	(0.027)**	(0.028)**	(0.029)**	(0.028)**	(0.031)**	(0.028)**
[D1]	0.702	0.751	0.672	0.602	0.621	0.562	0.49	0.532	0.587
	(0.025)**	(0.026)**	(0.025)**	(0.026)**	(0.027)**	(0.027)**	(0.026)**	(0.03)**	(0.026)**
[D2]	0.657	0.713	0.632	0.585	0.601	0.537	0.465	0.488	0.545
	(0.026)**	(0.026)**	(0.025)**	(0.026)**	(0.027)**	(0.028)**	(0.027)**	(0.03)**	(0.026)**
[E1]	0.729	0.776	0.706	0.638	0.703	0.638	0.537	0.589	0.662
	(0.028)**	(0.029)**	(0.028)**	(0.029)**	(0.03)**	(0.03)**	(0.03)**	(0.033)**	(0.029)**
[E2]	0.792	0.874	0.798	0.753	0.797	0.771	0.697	0.756	0.835
	(0.035)**	(0.035)**	(0.033)**	(0.033)**	(0.035)**	(0.036)**	(0.035)**	(0.038)**	(0.035)**
[E3]	0.762	0.787	0.756	0.733	0.771	0.708	0.577	0.643	0.705
	(0.035)**	(0.036)**	(0.034)**	(0.035)**	(0.037)**	(0.037)**	(0.038)**	(0.042)**	(0.037)**
[F1]	0.63	0.682	0.641	0.584	0.605	0.554	0.461	0.514	0.534
	(0.029)**	(0.029)**	(0.028)**	(0.029)**	(0.03)**	(0.03)**	(0.029)**	(0.032)**	(0.029)**
[F2]	0.453	0.488	0.44	0.392	0.409	0.336	0.27	0.288	0.338
	(0.026)**	(0.027)**	(0.026)**	(0.026)**	(0.027)**	(0.028)**	(0.027)**	(0.03)**	(0.026)**
[G]	0.665	0.718	0.65	0.594	0.623	0.564	0.465	0.478	0.552
	(0.028)**	(0.029)**	(0.027)**	(0.028)**	(0.029)**	(0.029)**	(0.029)**	(0.032)**	(0.028)**
[H]	0.586	0.645	0.583	0.497	0.522	0.42	0.345	0.382	0.389
	(0.031)**	(0.031)**	(0.029)**	(0.03)**	(0.031)**	(0.031)**	(0.031)**	(0.034)**	(0.03)**
[I]	0.114	0.206	0.167	0.096	0.113	0.099	-0.041	-0.012	0.06
	(0.029)**	(0.03)**	(0.029)**	(0.03)**	(0.032)**	(0.033)**	(0.032)**	(0.036)**	(0.032)**
[J]	0.603	0.597	0.521	0.5	0.486	0.376	0.223	0.111	0.417
	(0.041)**	(0.041)**	(0.04)**	(0.04)**	(0.043)**	(0.043)**	(0.042)**	(0.045)**	(0.042)**

Continued on next page

	Year								
[K]	0.465	0.536	0.448	0.441	0.486	0.422	0.336	0.374	0.449
	(0.028)**	(0.028)**	(0.027)**	(0.027)**	(0.029)**	(0.029)**	(0.028)**	(0.031)**	(0.027)**
N	35395	35461	34109	34085	32526	32444	32294	31485	32925
R^2	0.418	0.404	0.424	0.399	0.395	0.388	0.392	0.358	0.377
	1977	1978	1979	1980	1981	1982	1983	1984	1985
[B]	0.719	0.761	0.713	0.791	0.788	0.768	0.913	0.742	0.822
	(0.035)**	(0.035)**	(0.035)**	(0.033)**	(0.031)**	(0.033)**	(0.034)**	(0.039)**	(0.037)**
[C]	0.466	0.543	0.426	0.438	0.501	0.414	0.479	0.399	0.436
	(0.025)**	(0.025)**	(0.026)**	(0.024)**	(0.024)**	(0.026)**	(0.027)**	(0.029)**	(0.028)**
[D1]	0.568	0.621	0.526	0.567	0.599	0.551	0.606	0.535	0.614
	(0.024)**	(0.024)**	(0.025)**	(0.023)**	(0.022)**	(0.024)**	(0.025)**	(0.027)**	(0.026)**
[D2]	0.524	0.588	0.477	0.516	0.553	0.486	0.543	0.498	0.548
	(0.024)**	(0.024)**	(0.025)**	(0.023)**	(0.023)**	(0.025)**	(0.025)**	(0.028)**	(0.027)**
[E1]	0.622	0.674	0.572	0.6	0.639	0.578	0.623	0.557	0.584
	(0.027)**	(0.027)**	(0.028)**	(0.026)**	(0.025)**	(0.028)**	(0.028)**	(0.031)**	(0.03)**
[E2]	0.836	0.836	0.755	0.778	0.802	0.74	0.852	0.782	0.817
	(0.032)**	(0.032)**	(0.033)**	(0.03)**	(0.03)**	(0.032)**	(0.033)**	(0.035)**	(0.034)**
[E3]	0.663	0.757	0.62	0.667	0.737	0.713	0.801	0.742	0.784
	(0.034)**	(0.034)**	(0.035)**	(0.032)**	(0.032)**	(0.035)**	(0.035)**	(0.037)**	(0.037)**
[F1]	0.527	0.605	0.456	0.502	0.538	0.494	0.576	0.476	0.561
	(0.026)**	(0.026)**	(0.027)**	(0.025)**	(0.025)**	(0.027)**	(0.027)**	(0.03)**	(0.029)**
[F2]	0.31	0.351	0.264	0.273	0.3	0.218	0.299	0.231	0.286
	(0.024)**	(0.024)**	(0.025)**	(0.023)**	(0.023)**	(0.025)**	(0.025)**	(0.027)**	(0.026)**
[G]	0.516	0.586	0.469	0.503	0.543	0.477	0.548	0.482	0.568
	(0.026)**	(0.026)**	(0.027)**	(0.025)**	(0.024)**	(0.026)**	(0.027)**	(0.029)**	(0.028)**
[H]	0.369	0.461	0.343	0.386	0.438	0.365	0.418	0.366	0.411
	(0.027)**	(0.027)**	(0.028)**	(0.026)**	(0.025)**	(0.027)**	(0.027)**	(0.03)**	(0.028)**
[I]	0.004	0.11	0.012	-0.007	0.074	0.021	0.063	0.003	0.116
	(0.03)**	(0.03)**	(0.031)**	(0.028)**	(0.028)**	(0.03)**	(0.031)**	(0.033)**	(0.032)**
[J]	0.275	0.369	0.182	0.289	0.307	0.282	0.317	0.224	0.38
	(0.037)**	(0.037)**	(0.038)**	(0.036)**	(0.034)**	(0.037)**	(0.039)**	(0.041)**	(0.039)**
[K]	0.42	0.484	0.361	0.384	0.425	0.385	0.446	0.361	0.475
	(0.025)**	(0.025)**	(0.026)**	(0.024)**	(0.023)**	(0.025)**	(0.026)**	(0.028)**	(0.027)**
N	39410	39524	40483	48256	48277	43157	41874	41710	43914
R^2	0.372	0.38	0.357	0.344	0.336	0.332	0.31	0.28	0.311
	1986	1987	1988	1989	1990	1991	1992	1993	1994
[B]	0.784	0.828	0.85	0.933	0.892	0.95	0.818	0.848	0.812
	(0.037)**	(0.039)**	(0.037)**	(0.039)**	(0.038)**	(0.036)**	(0.039)**	(0.04)**	(0.043)**
[C]	0.392	0.48	0.526	0.565	0.584	0.597	0.424	0.464	0.398
	(0.027)**	(0.027)**	(0.024)**	(0.024)**	(0.024)**	(0.024)**	(0.024)**	(0.025)**	(0.026)**
[D1]	0.568	0.632	0.693	0.686	0.725	0.712	0.618	0.648	0.565
	(0.025)**	(0.025)**	(0.023)**	(0.023)**	(0.023)**	(0.022)**	(0.023)**	(0.023)**	(0.025)**
[D2]	0.502	0.547	0.618	0.623	0.679	0.661	0.558	0.577	0.509
	(0.026)**	(0.026)**	(0.023)**	(0.024)**	(0.023)**	(0.023)**	(0.023)**	(0.024)**	(0.025)**
[E1]	0.526	0.621	0.662	0.663	0.664	0.668	0.55	0.587	0.53
	(0.029)**	(0.029)**	(0.026)**	(0.026)**	(0.026)**	(0.025)**	(0.026)**	(0.026)**	(0.028)**
[E2]	0.796	0.863	0.903	0.883	0.908	0.916	0.787	0.839	0.745
	(0.034)**	(0.035)**	(0.031)**	(0.032)**	(0.032)**	(0.031)**	(0.032)**	(0.034)**	(0.037)**
[E3]	0.705	0.822	0.904	0.851	0.868	0.897	0.815	0.862	0.752
	(0.036)**	(0.036)**	(0.033)**	(0.034)**	(0.033)**	(0.033)**	(0.033)**	(0.033)**	(0.037)**
[F1]	0.491	0.567	0.594	0.599	0.648	0.663	0.572	0.595	0.502
	(0.028)**	(0.028)**	(0.025)**	(0.026)**	(0.025)**	(0.025)**	(0.025)**	(0.026)**	(0.027)**
[F2]	0.225	0.303	0.376	0.365	0.386	0.395	0.3	0.32	0.227
	(0.026)**	(0.025)**	(0.023)**	(0.023)**	(0.023)**	(0.022)**	(0.023)**	(0.023)**	(0.024)**
[G]	0.492	0.59	0.655	0.64	0.677	0.691	0.566	0.604	0.535
	(0.027)**	(0.027)**	(0.024)**	(0.024)**	(0.024)**	(0.024)**	(0.024)**	(0.025)**	(0.026)**
[H]	0.342	0.417	0.475	0.476	0.523	0.526	0.417	0.44	0.355
	(0.027)**	(0.027)**	(0.024)**	(0.024)**	(0.024)**	(0.024)**	(0.024)**	(0.025)**	(0.026)**
[I]	0.045	0.158	0.127	0.169	0.24	0.245	0.136	0.216	0.119
	(0.031)**	(0.031)**	(0.028)**	(0.028)**	(0.027)**	(0.027)**	(0.027)**	(0.028)**	(0.03)**
[J]	0.26	0.338	0.409	0.35	0.399	0.516	0.311	0.377	0.321
	(0.039)**	(0.038)**	(0.034)**	(0.035)**	(0.034)**	(0.034)**	(0.032)**	(0.032)**	(0.034)**
[K]	0.391	0.454	0.509	0.513	0.544	0.561	0.466	0.51	0.424
	(0.026)**	(0.026)**	(0.023)**	(0.024)**	(0.023)**	(0.023)**	(0.023)**	(0.024)**	(0.025)**
N	43702	43670	45282	42437	46426	46106	45023	44022	42638
R^2	0.319	0.323	0.337	0.336	0.332	0.327	0.318	0.318	0.313
	1995	1996	1997	1998	1999	2000	2001	2002	2003
[B]	0.786	0.693	0.713	0.786	0.676	0.716	0.667	0.611	0.523
	(0.041)**	(0.048)**	(0.047)**	(0.048)**	(0.048)**	(0.049)**	(0.05)**	(0.039)**	(0.04)**

Continued on next page

	Year								
[C]	0.377	0.402	0.368	0.456	0.373	0.364	0.385	0.347	0.269
	(0.024)**	(0.026)**	(0.026)**	(0.027)**	(0.027)**	(0.026)**	(0.026)**	(0.021)**	(0.02)**
[D1]	0.542	0.516	0.496	0.578	0.526	0.524	0.502	0.46	0.357
	(0.023)**	(0.025)**	(0.024)**	(0.026)**	(0.025)**	(0.025)**	(0.025)**	(0.02)**	(0.02)**
[D2]	0.488	0.465	0.453	0.527	0.45	0.481	0.444	0.419	0.316
	(0.024)**	(0.026)**	(0.026)**	(0.027)**	(0.027)**	(0.026)**	(0.026)**	(0.021)**	(0.021)**
[E1]	0.446	0.451	0.435	0.515	0.423	0.426	0.41	0.414	0.278
	(0.026)**	(0.028)**	(0.028)**	(0.029)**	(0.028)**	(0.028)**	(0.028)**	(0.022)**	(0.023)**
[E2]	0.708	0.684	0.607	0.726	0.666	0.665	0.661	0.634	0.487
	(0.034)**	(0.039)**	(0.038)**	(0.038)**	(0.036)**	(0.035)**	(0.034)**	(0.027)**	(0.028)**
[E3]	0.687	0.707	0.709	0.809	0.699	0.671	0.678	0.615	0.548
	(0.035)**	(0.038)**	(0.039)**	(0.039)**	(0.04)**	(0.039)**	(0.04)**	(0.032)**	(0.032)**
[F1]	0.488	0.446	0.433	0.545	0.464	0.435	0.457	0.44	0.325
	(0.026)**	(0.028)**	(0.028)**	(0.029)**	(0.028)**	(0.027)**	(0.027)**	(0.022)**	(0.023)**
[F2]	0.243	0.21	0.209	0.269	0.22	0.19	0.184	0.169	0.132
	(0.023)**	(0.024)**	(0.024)**	(0.026)**	(0.025)**	(0.025)**	(0.025)**	(0.02)**	(0.019)**
[G]	0.522	0.502	0.491	0.583	0.513	0.548	0.519	0.527	0.406
	(0.025)**	(0.026)**	(0.026)**	(0.028)**	(0.027)**	(0.026)**	(0.026)**	(0.021)**	(0.021)**
[H]	0.343	0.333	0.332	0.404	0.392	0.388	0.39	0.377	0.27
	(0.024)**	(0.026)**	(0.026)**	(0.027)**	(0.026)**	(0.026)**	(0.025)**	(0.021)**	(0.021)**
[I]	0.113	0.062	0.105	0.2	0.082	0.082	0.117	0.128	0.051
	(0.028)**	(0.03)**	(0.03)**	(0.032)**	(0.031)**	(0.03)**	(0.03)**	(0.024)**	(0.024)**
[J]	0.318	0.327	0.301	0.336	0.267	0.312	0.232	0.219	0.161
	(0.032)**	(0.035)**	(0.034)**	(0.035)**	(0.033)**	(0.033)**	(0.033)**	(0.026)**	(0.026)**
[K]	0.395	0.401	0.383	0.45	0.386	0.366	0.352	0.337	0.275
	(0.023)**	(0.025)**	(0.025)**	(0.026)**	(0.026)**	(0.025)**	(0.025)**	(0.02)**	(0.02)**
N	43632	39341	40481	40361	41251	42345	41379	66856	65060
R^2	0.316	0.304	0.302	0.305	0.322	0.32	0.329	0.32	0.307

	2004	2005	2006	2007	2008
[B]	0.647	0.667	0.732	0.647	0.682
	(0.041)**	(0.041)**	(0.038)**	(0.039)**	(0.037)**
[C]	0.362	0.311	0.327	0.27	0.299
	(0.021)**	(0.022)**	(0.021)**	(0.021)**	(0.02)**
[D1]	0.459	0.403	0.434	0.364	0.436
	(0.02)**	(0.022)**	(0.02)**	(0.021)**	(0.02)**
[D2]	0.413	0.373	0.393	0.343	0.382
	(0.021)**	(0.023)**	(0.021)**	(0.022)**	(0.021)**
[E1]	0.397	0.35	0.389	0.284	0.321
	(0.023)**	(0.025)**	(0.023)**	(0.024)**	(0.023)**
[E2]	0.608	0.569	0.599	0.498	0.518
	(0.03)**	(0.034)**	(0.032)**	(0.032)**	(0.031)**
[E3]	0.679	0.589	0.626	0.572	0.632
	(0.035)**	(0.037)**	(0.035)**	(0.038)**	(0.034)**
[F1]	0.432	0.383	0.408	0.345	0.418
	(0.022)**	(0.024)**	(0.023)**	(0.024)**	(0.023)**
[F2]	0.2	0.165	0.165	0.105	0.163
	(0.02)**	(0.021)**	(0.02)**	(0.021)**	(0.019)**
[G]	0.503	0.46	0.501	0.467	0.467
	(0.021)**	(0.022)**	(0.021)**	(0.022)**	(0.021)**
[H]	0.376	0.324	0.368	0.323	0.334
	(0.021)**	(0.022)**	(0.021)**	(0.022)**	(0.02)**
[I]	0.09	0.079	0.101	0.045	0.069
	(0.024)**	(0.026)**	(0.025)**	(0.026)**	(0.024)**
[J]	0.274	0.186	0.27	0.192	0.232
	(0.026)**	(0.027)**	(0.026)**	(0.027)**	(0.025)**
[K]	0.368	0.3	0.347	0.277	0.325
	(0.02)**	(0.021)**	(0.02)**	(0.021)**	(0.02)**
N	63581	59905	60302	60533	60521
R^2	0.304	0.299	0.32	0.298	0.317

Standard errors in parenthesis. $**$: significant at 1% confidence level; $*$: significant at 5% confidence level.

Table 2.12: Hourly wage estimates

	Year							
	1990	1991	1992	1993	1994	1995	1996	1997
[B]	0.885	0.941	0.811	0.843	0.808	0.782	0.685	0.708
	(0.038)**	(0.036)**	(0.039)**	(0.039)**	(0.043)**	(0.041)**	(0.048)**	(0.047)**
[C]	0.58	0.593	0.419	0.46	0.394	0.374	0.399	0.363
	(0.024)**	(0.024)**	(0.024)**	(0.025)**	(0.026)**	(0.024)**	(0.026)**	(0.026)**
[D1]	0.718	0.707	0.611	0.643	0.56	0.538	0.511	0.491
	(0.023)**	(0.022)**	(0.023)**	(0.023)**	(0.024)**	(0.023)**	(0.025)**	(0.024)**
[D2]	0.673	0.657	0.551	0.572	0.504	0.484	0.461	0.448
	(0.023)**	(0.023)**	(0.023)**	(0.024)**	(0.025)**	(0.024)**	(0.026)**	(0.026)**
[E1]	0.655	0.659	0.54	0.579	0.522	0.439	0.443	0.428
	(0.026)**	(0.025)**	(0.026)**	(0.026)**	(0.028)**	(0.026)**	(0.028)**	(0.028)**
[E2]	0.894	0.906	0.77	0.824	0.731	0.696	0.672	0.595
	(0.032)**	(0.031)**	(0.032)**	(0.034)**	(0.037)**	(0.034)**	(0.039)**	(0.038)**
[E3]	0.858	0.889	0.801	0.853	0.744	0.678	0.698	0.7
	(0.033)**	(0.033)**	(0.033)**	(0.033)**	(0.037)**	(0.035)**	(0.038)**	(0.039)**
[F1]	0.646	0.662	0.571	0.593	0.501	0.487	0.445	0.431
	(0.025)**	(0.025)**	(0.025)**	(0.026)**	(0.027)**	(0.026)**	(0.028)**	(0.028)**
[F2]	0.384	0.394	0.298	0.318	0.226	0.242	0.208	0.207
	(0.023)**	(0.022)**	(0.023)**	(0.023)**	(0.024)**	(0.023)**	(0.024)**	(0.024)**
[G]	0.676	0.691	0.564	0.604	0.535	0.522	0.501	0.49
	(0.024)**	(0.024)**	(0.024)**	(0.025)**	(0.026)**	(0.025)**	(0.026)**	(0.026)**
[H]	0.521	0.526	0.416	0.438	0.355	0.343	0.332	0.33
	(0.024)**	(0.024)**	(0.024)**	(0.025)**	(0.026)**	(0.024)**	(0.026)**	(0.026)**
[I]	0.238	0.244	0.132	0.214	0.118	0.112	0.06	0.104
	(0.027)**	(0.027)**	(0.027)**	(0.028)**	(0.03)**	(0.028)**	(0.03)**	(0.03)**
[J]	0.396	0.513	0.307	0.372	0.318	0.315	0.323	0.297
	(0.034)**	(0.034)**	(0.032)**	(0.032)**	(0.034)**	(0.032)**	(0.035)**	(0.034)**
[K]	0.54	0.559	0.462	0.507	0.422	0.393	0.398	0.38
	(0.023)**	(0.023)**	(0.023)**	(0.024)**	(0.025)**	(0.023)**	(0.025)**	(0.025)**
N	46426	46106	45023	44022	42638	43632	39341	40481
R^2	0.333	0.328	0.319	0.319	0.314	0.316	0.304	0.303

	1998	1999	2000	2001	2002	2003	2004	2005
[B]	0.782	0.674	0.715	0.665	0.61	0.521	0.644	0.664
	(0.048)**	(0.048)**	(0.049)**	(0.05)**	(0.039)**	(0.04)**	(0.041)**	(0.041)**
[C]	0.452	0.369	0.361	0.382	0.345	0.265	0.36	0.31
	(0.027)**	(0.027)**	(0.026)**	(0.026)**	(0.021)**	(0.02)**	(0.021)**	(0.022)**
[D1]	0.574	0.522	0.522	0.5	0.458	0.353	0.456	0.4
	(0.026)**	(0.025)**	(0.025)**	(0.025)**	(0.02)**	(0.02)**	(0.02)**	(0.022)**
[D2]	0.522	0.447	0.479	0.442	0.417	0.313	0.41	0.37
	(0.027)**	(0.027)**	(0.026)**	(0.026)**	(0.021)**	(0.021)**	(0.021)**	(0.023)**
[E1]	0.507	0.416	0.422	0.407	0.41	0.272	0.392	0.346
	(0.029)**	(0.028)**	(0.028)**	(0.028)**	(0.022)**	(0.023)**	(0.023)**	(0.025)**
[E2]	0.711	0.652	0.659	0.656	0.63	0.481	0.604	0.565
	(0.038)**	(0.036)**	(0.035)**	(0.034)**	(0.027)**	(0.028)**	(0.03)**	(0.034)**
[E3]	0.799	0.693	0.665	0.673	0.61	0.541	0.671	0.584
	(0.039)**	(0.04)**	(0.039)**	(0.04)**	(0.032)**	(0.032)**	(0.035)**	(0.037)**
[F1]	0.544	0.464	0.434	0.456	0.44	0.324	0.432	0.383
	(0.029)**	(0.028)**	(0.027)**	(0.027)**	(0.022)**	(0.022)**	(0.022)**	(0.024)**
[F2]	0.267	0.219	0.189	0.183	0.168	0.131	0.199	0.165
	(0.026)**	(0.025)**	(0.025)**	(0.025)**	(0.02)**	(0.019)**	(0.02)**	(0.021)**
[G]	0.582	0.513	0.548	0.519	0.527	0.406	0.503	0.46
	(0.028)**	(0.027)**	(0.026)**	(0.026)**	(0.021)**	(0.021)**	(0.021)**	(0.022)**
[H]	0.403	0.392	0.388	0.39	0.377	0.269	0.375	0.324
	(0.027)**	(0.026)**	(0.026)**	(0.025)**	(0.021)**	(0.021)**	(0.021)**	(0.022)**
[I]	0.197	0.08	0.081	0.116	0.127	0.05	0.089	0.078
	(0.032)**	(0.031)**	(0.03)**	(0.03)**	(0.024)**	(0.024)**	(0.024)**	(0.026)**
[J]	0.332	0.263	0.31	0.231	0.218	0.16	0.272	0.185
	(0.035)**	(0.033)**	(0.033)**	(0.033)**	(0.026)**	(0.026)**	(0.026)**	(0.027)**
[K]	0.447	0.384	0.364	0.351	0.336	0.273	0.366	0.298
	(0.026)**	(0.026)**	(0.025)**	(0.025)**	(0.02)**	(0.02)**	(0.02)**	(0.021)**
N	40361	41251	42345	41379	66856	65060	63581	59905
R^2	0.306	0.322	0.32	0.329	0.32	0.307	0.304	0.3

	2006	2007	2008
[B]	0.73	0.645	0.68
	(0.038)**	(0.039)**	(0.037)**
[C]	0.324	0.268	0.298
	(0.021)**	(0.021)**	(0.02)**
[D1]	0.432	0.362	0.435
	(0.02)**	(0.021)**	(0.02)**

Continued on next page

	Year		
[D2]	0.391	0.341	0.381
	(0.021)**	(0.022)**	(0.021)**
[E1]	0.387	0.281	0.318
	(0.023)**	(0.024)**	(0.023)**
[E2]	0.595	0.493	0.514
	(0.032)**	(0.032)**	(0.031)**
[E3]	0.621	0.565	0.628
	(0.035)**	(0.038)**	(0.034)**
[F1]	0.408	0.344	0.418
	(0.023)**	(0.024)**	(0.023)**
[F2]	0.165	0.104	0.162
	(0.02)**	(0.021)**	(0.019)**
[G]	0.501	0.467	0.467
	(0.021)**	(0.022)**	(0.021)**
[H]	0.368	0.322	0.333
	(0.021)**	(0.022)**	(0.02)**
[I]	0.1	0.044	0.069
	(0.025)**	(0.026)**	(0.024)**
[J]	0.269	0.191	0.23
	(0.026)**	(0.027)**	(0.025)**
[K]	0.345	0.276	0.324
	(0.02)**	(0.021)**	(0.02)**
N	60302	60533	60521
R^2	0.321	0.299	0.317

Standard errors in parenthesis. **: significant at 1% confidence level;
*: significant at 5% confidence level.

Table 2.12 contains selected parameters related to industry dummies, along with the sample size and adjusted R^2 for the regressions including 15 industries; the dependent variable is hourly wage.

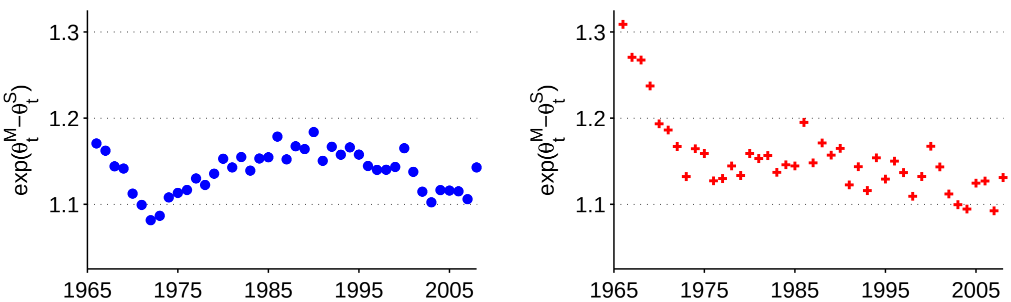
Estimates summarized in Tables 2.11 and 2.12 include dummies for female workers, African-American workers, living a metropolitan area, division of residence, age group, and educational attainment. Additionally, regressions of hourly wage on individual characteristics include a dummy for union coverage.

2.E Empirical estimates: 1962-2008

This appendix presents the wage differentials between manufacturing and services (equation 2.11) using estimates from equation (2.9). These estimates employ the third data set in Table 2.1, which stretches back to 1962.

Two remarks are necessary. First, as discussed in Section 2.4, these data can only be aggregated into major sectors since no harmonized industry variable is available for the entire time period. Hence, I aggregate data according to option 1 (Table 2.5) using the unharmonized IPUMS-CPS data IND. Details on sectoral aggregation are available upon request. Second, I only estimated regressions with wage/salary income as dependent variable. Hourly wage is only available for nineteen years and the purpose of this exercise is to estimate differentials for the longest period of time possible.

Manufacturing and Service sector dummies are statistically significant and the wage differential estimates (depicted in Figure 2.5) are different from one. Moreover, these estimates are not statistically different (for comparable years) to those obtained by aggregation from the harmonized industry variable (IND1950). Yet, as in the previously discussed estimates, there is a difference between the trend of wage differentials obtained from the pool of male and female workers and the one obtained from male workers only. In particular, the inclusion of female workers in the sample is consistent with a deviation from the long-run decreasing trend in wage differentials.



(a) All workers (b) Male workers

Figure 2.5: Income differentials: unharmonized variable IND

Chapter 3

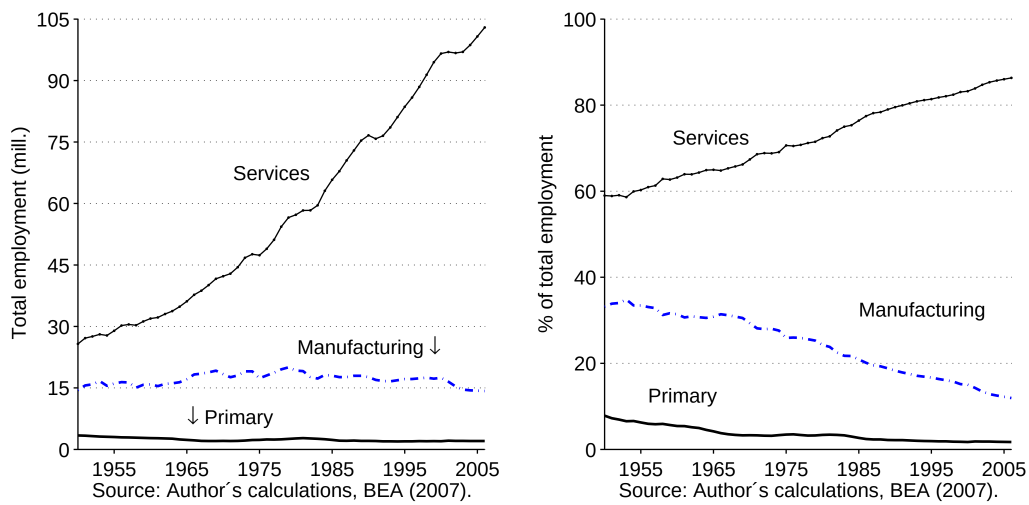
The role of labor markets in structural change

3.1 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 3.1).

On the other hand, changes in employment compensation are less well understood in the context of structural transformation. The average wage per worker in manufacturing[1] was higher than in services and increased relative to this sector between 1950 and 2000 (Figure 3.2a). However, when corrected for individual characteristics (see discussion in Section 3.2 and Appendix 3.B.1), relative wages showed an overall decreasing trend between 1962 and 2008 (Figure 3.2b). These two observations suggest that increasing average wages are the product of improvements in the quality of

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



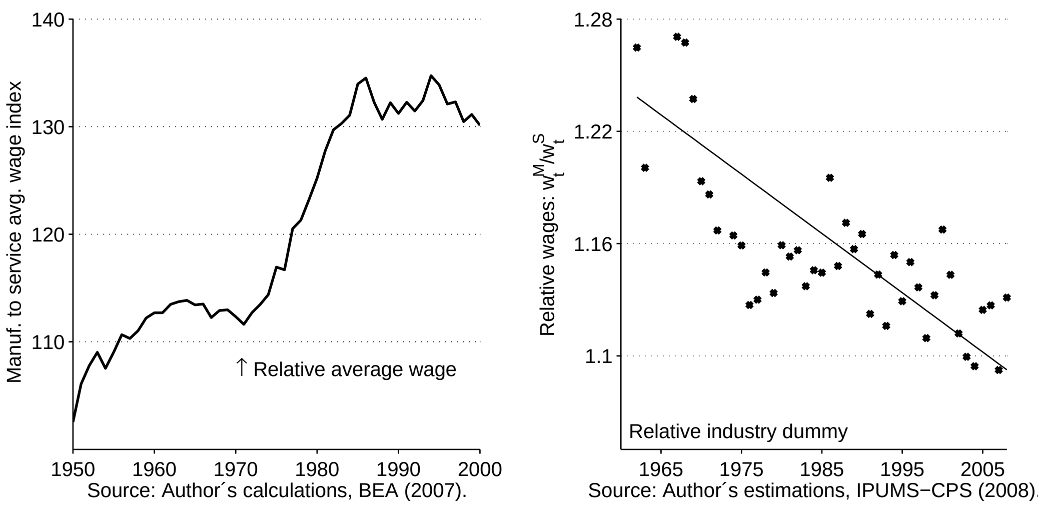
(a) MM workers (b) % labor force

Figure 3.1: Sectoral employment

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.

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



(a) Worker compensation (b) Wages, controlled for indiv. characteristics

Figure 3.2: Sectoral wages

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-homotethic 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.

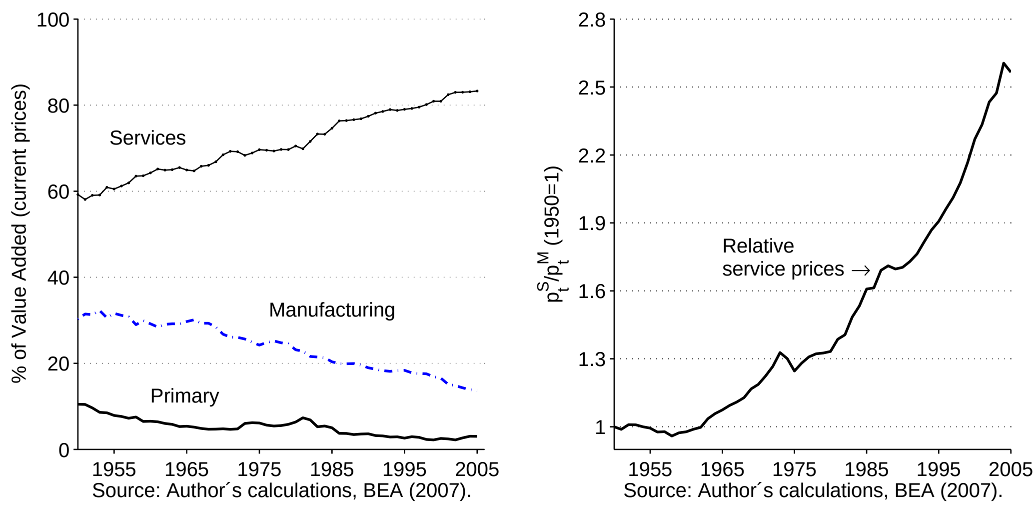
This paper is organized as follows: Section 3.2 discusses empirical observations on structural change and non-competitive labor markets. In Section 3.3, I present the model and characterize the equilibrium. I calibrate the model in Section 3.4. The benchmark calibration is for the United States economy, 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 3.5.

3.2 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 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.

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

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



(a) Sectoral output shares

(b) Services (relative to Manufacturing) prices

Figure 3.3: Output and prices

more than 20 percentage points while that of the manufacturing sector fell, as depicted in Figure 3.3a 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 3.3b. 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 3.2a). 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 (3.B.1) describes the regression equation for each year t.

$$\begin{aligned}\log w_{j,t} - \log \overline{w}_t =& \tilde{\mathbf{x}}_{j,t}\mathbf{B}_t + \tilde{\gamma}_{j,t}\boldsymbol{\Theta}_t + \eta_{j,t} \\ =& \beta_t^0 + \beta_t^b \tilde{D}_{j,t}^b + \beta_t^m \tilde{D}_{j,t}^m + \sum_{r\in R} \beta_t^r \tilde{D}_{j,t}^r \\ &+ \sum_{e\in E} \beta_t^e \tilde{D}_{j,t}^e + \sum_{a\in A} \beta_t^a \tilde{D}_{j,t}^a + \sum_{s\in S} \theta_t^s \tilde{D}_{j,t}^s + \eta_{j,t} \end{aligned} \tag{3.1}$$

where $\tilde{x} \equiv x - \overline{x}$, the individual deviation from the sample mean $\overline{x}$. 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 3.2b and the estimated values are reported in Appendix 3.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 3.7.[3] Differentials can be attributed to differences in the degree of labor market imperfections between the two sectors.

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

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]

3.3 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 heterogenous households whose preferences are represented by a CES utility function over two goods: manufactures and services. Households choose how 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.

[4]Monetary, 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).

3.3.1 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:

$$\sum_{t=0}^{\infty} \beta^t \left[\log \left[\gamma \left(c_t^M(h) \right)^{\phi} + (1-\gamma) \left(c_t^S(h) \right)^{\phi} \right]^{\frac{1}{\phi}} \right], \tag{3.2}$$

where

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

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:

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

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.

[5]Cobb-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.

[6]Empirical 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).

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:

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

$$\text{s.t.} \tag{3.3}$$

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

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

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 $\left\{ c_t^M(h), c_t^S(h) \right\}$ given the household's income. This is needed to solve the bargaining problem, which I discuss in detail in Section 3.3.4.

3.3.2 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

[7] For a detailed treatment of the wage bargaining process, see Section 3.3.4.

technology:

$$C_t^S \leq A_t^S L_t^S, \tag{3.4}$$

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:

$$\max_{\{L_t^S\}} \left\{ p_t^S A_t^S L_t^S - w_t^S L_t^S \right\} \tag{3.5}$$

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

3.3.3 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:

$$\max_{p_t^M(i), l_t^M(i)} \left\{ p_t^M(i) c^M(p_t^M(i), P_t^M) - w_t^M(i) l_t^M(i) \right\}$$
$$\text{s.t.} \tag{3.6}$$
$$c^M(p_t^M(i), P_t^M) \leq A_t^M l_t^M(i)$$

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.

3.3.4 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:*

$$w_t^M h - \kappa \geq w_t^S h. \tag{3.7}$$

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

Proof First, I solve the consumer's problem (3.3), given income $Y_t(h)$, to obtain the optimal basket of consumption:

$$\left\{c_t^M(h), c_t^S(h)\right\} = \frac{Y_t(h)}{(1-\gamma)^{\frac{1}{\phi-1}} P_t^{M\,\frac{\phi}{\phi-1}} + \gamma^{\frac{1}{\phi-1}} p_t^{S\,\frac{\phi}{\phi-1}}} \left\{(1-\gamma)^{\frac{1}{\phi-1}} P_t^{M\,\frac{1}{\phi-1}}, \gamma^{\frac{1}{\phi-1}} p_t^{S\,\frac{1}{\phi-1}}\right\}, \tag{3.8}$$

where P_t^M is the price of the manufacturing composite. I plug (3.8) 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, (3.7) implies that $V\left(w_t^M h - \kappa; \cdot\right) \geq V\left(w_t^S h; \cdot\right)$. 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 3.4).

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):

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

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 $\overline{h}(h^*(W^M)) \equiv E(h|h \geq h^*(W^M)) = \frac{b}{b-1}h^*(W^M)$, 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 (3.7), 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 3.4.

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

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

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

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

On the other hand, a firm seeks to maximize profits, compared to the alternative

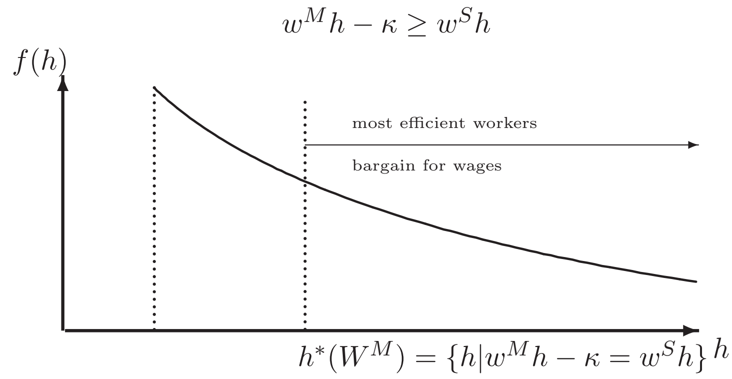


Figure 3.4: Worker productivity cutoff

of not reaching an agreement and shutting down. Profit as a function of the bargained wage comes from solving firm i's problem (3.6). 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:

$$\Omega(w^M(i)) = \rho \log \left(\left[w^M(i) - w^S - \frac{\kappa}{\bar{h}^M(\cdot)} \right] l^M(w^M(i)) \right) + (1-\rho) \log \left(\pi(w^M(i)) \right), \tag{3.9}$$

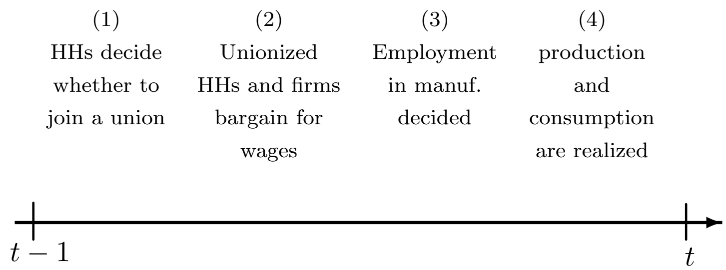
where ρ is the union's bargaining power, which I assume identical across all union-firm pairs. Notice that since I assumed the firm and union are very small, their decisions

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

do not affect h^* (through $\overline{h}^M(\cdot)$), the cutoff level of labor productivity, or any other aggregate variable.

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

Timing:



3.3.5 Market clearing conditions

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

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

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

3.3.6 Equilibrium characterization

Equilibrium consists of quantities $\left\{\{c_t^M(i,h)\}_{i=0}^I, c_t^S(h)\right\}$ and a cutoff h_t^* that solve the households' (3.3) and firms' (3.5 and 3.6) 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 (3.9), 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 $\left\{c_t^M(h), c_t^S(h)\right\}$. 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:

$$c_t^M(i,h;p_t^M) = \frac{p_t^M(i)^{\frac{1}{\epsilon-1}}}{P_t^{M\,\frac{1}{\epsilon-1}}} c_t^M(h;P_t^M), \tag{3.10}$$

where $P_t^M = \left(\int_0^I p_t^M(i)^{\frac{\epsilon}{\epsilon-1}} di\right)^{\frac{\epsilon-1}{\epsilon}}$. Plugging equation (3.10) into the manufacturing firm's profit maximization problem, yields the price for good i:

$$p_t^M(i) = \left[\frac{1}{\epsilon}\frac{w_t^M(i)}{A_t^M}\right] \tag{3.11}$$

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:

$$l_t^M(w_t^M(i)) = \left[\frac{w_t^M(i)^{\frac{1}{\epsilon-1}}}{A_t^{M\,\frac{\epsilon}{\epsilon-1}}}\right]\frac{C_t^M}{(\epsilon P_t^M)^{\frac{1}{\epsilon-1}}}, \tag{3.12}$$

$$\pi_t(w_t^M(i)) = \left[\frac{w_t^M(i)}{A_t^M}\right]^{\frac{\epsilon}{\epsilon-1}}\frac{C_t^M}{(\epsilon P_t^M)^{\frac{1}{\epsilon-1}}}\frac{1-\epsilon}{\epsilon}. \tag{3.13}$$

Next, I solve the bargaining problem (3.9) to obtain the wage. The first order condition can be manipulated to obtain:

$$w^M(h_t^*) = \left[1 + \underbrace{\left(\rho\right)}_{(1)}\underbrace{\left(\frac{1}{\epsilon} - 1\right)}_{(2)}\right]\left[w_t^S + \underbrace{\frac{\kappa}{\overline{h}^M(h_t^*)}}_{(3)}\right]. \tag{3.14}$$

Equation (3.14) 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 (3.10) 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 (3.10) to obtain:

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

With the condition above, sectoral output in equilibrium is:

$$C_t^S = A_t^S L_t^S, \tag{3.15}$$
$$C_t^M = I^{\frac{1}{\epsilon}} c_t^M = A_t^M (I^{\frac{1}{\epsilon}} l_t^M), \tag{3.16}$$

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

$$\frac{C_t^S}{C_t^M} = \left[\frac{\gamma}{(1-\gamma)} \frac{p_t^S}{P_t^M} \right]^{\frac{1}{\phi-1}}$$
$$\Rightarrow \frac{L_t^S}{L_t^M} = \left[\frac{\gamma}{(1-\gamma)} \frac{w_t^S}{w^M(h_t^*)} \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \right]^{\frac{1}{\phi-1}} \left[\frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}} \tag{3.17}$$

where last line used (3.15), (3.16), (3.11), 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 (3.17) 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:

$$L_t^S = \int_1^{h_t^*} h dF(h) = N_t^S \overline{h}^S(h_t^*),$$
$$L_t^M = \int_{h_t^*}^{\infty} h dF(h) = N_t^M \overline{h}^M(h_t^*).$$

Substituting these two expressions into (3.17), some manipulation yields:

$$\frac{N_t^S \overline{h}^S(h_t^*)}{N_t^M \overline{h}^M(h_t^*)} = \frac{(h_t^*)^b - h_t^*}{h_t^*} = \left[\frac{\gamma}{(1-\gamma)} \frac{w_t^S}{w^M(h_t^*)} \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \right]^{\frac{1}{\phi-1}} \left[\frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}}, \tag{3.18}$$

where I used the Pareto distribution for worker abilities. Equation (3.18) 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 (3.17), I obtain the ratio of current price consumption:

$$\frac{p_t^S C_t^S}{P_t^M C_t^M} = \left[\frac{\gamma}{(1-\gamma)}\right]^{\frac{1}{\phi-1}} \left[\frac{w_t^S}{w^M(h_t^*)} \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \frac{A_t^M}{A_t^S}\right]^{\frac{\phi}{\phi-1}}. \tag{3.19}$$

Conditions (3.14), (3.18), and (3.19), together with:

$$\frac{p_t^S}{P_t^M} = \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \frac{w_t^S}{w^M(h_t^*)} \frac{A_t^M}{A_t^S}, \tag{3.20}$$

complete the equilibrium characterization.

3.4 Calibration

In this section I show how the model presented in Section 3.3 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.

3.4.1 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 3.1 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 Appendix 3.B.1. I choose to match the year 2000 estimate, since my calibration sets parameters according to the end points of

Table 3.1: 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	$\frac{\frac{p^S C^S}{P^M C^M}}{\frac{N^S}{N^M}}$, 1950
b	2.1	Pareto distrib. shape param.	distribution of wages*
κ	0.362	bargaining cost	N^M_{2000}
ρ	0.437	union bargaining power	$\frac{w^M_{2000}}{w^S_{2000}}$
ϵ	0.870	inv. manuf. price markup	Bayoumi et al. (2004)
g_{A^M}	$(\star)$	manuf. output per worker growth	BEA
g_{A^S}	$(\star)$	serv. output per worker growth	BEA

$(\star)$: For construction details, see Data Description in Appendix 3.C.

$(*)$: Measured by Gini coefficient of 0.33, see discussion.

the selected period:[9]

$$\frac{w^M_{2000}}{w^S_{2000}} = 1.148.$$

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 3.C. Finally, notice that the elasticity of substitution parameter for consumption arising from the selected 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]

$$\frac{1}{1-\phi} \approx corr\left(\log\left(\frac{C^M_t}{C^S_t}\right), \log\left(\frac{P^M_t}{p^S_t}\right)\right) \in (0.338, 0.730).$$

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 (3.18) and nominal consumption (3.19) ratios, the change in relative prices (3.20) and wages (3.14), and the growth of constant-

[9]Calculated the relative wages from Jean and Nicoletti (2002) for 1998 are 1.107. For more details, see Appendix 3.B.2.

[10]This 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.

price sectoral output (consumption).

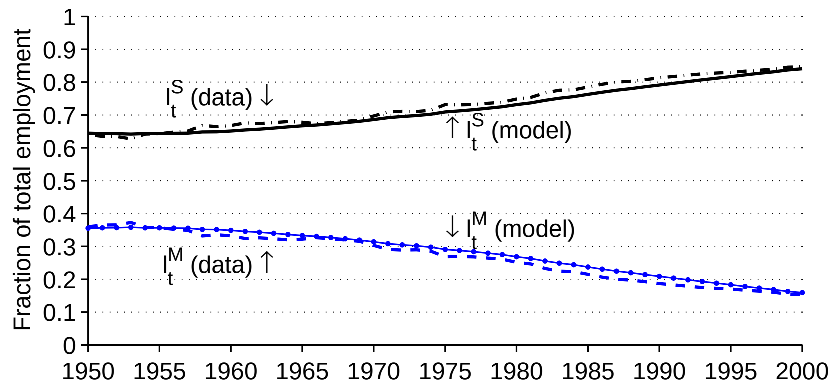


Figure 3.5: Sectoral shares of employment

I calibrate the model to match employment, which is depicted in Figure 3.5. Current price output shares are closely matched, as appears in Figure 3.6. Output per worker trends' (*i.e.,* HP-filter) growth rates for each sector are shown in Figures 3.7. 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

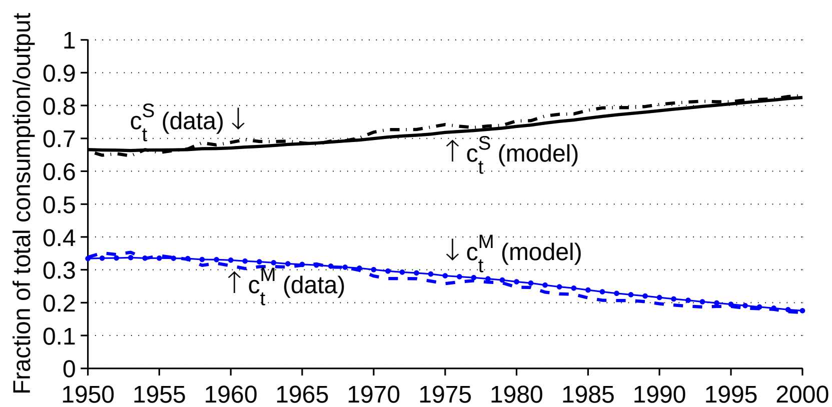
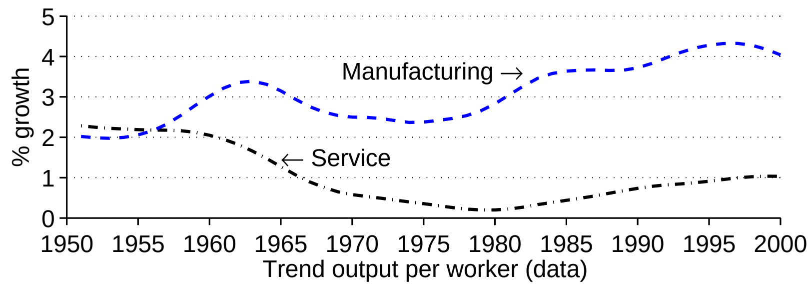
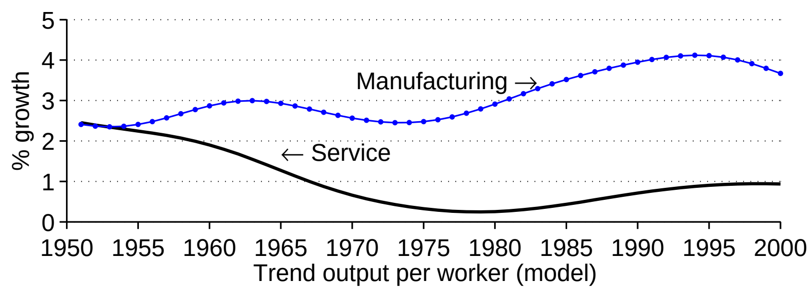


Figure 3.6: Sectoral shares of output, current prices

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



(a) Data



(b) Model

Figure 3.7: Sectoral output growth rate, constant prices

Relative sectoral wages decrease over time (see Figure 3.8). This trend is captured in equation (3.14). 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, $\frac{\kappa}{\bar{h}^M(\cdot)}$. Moreover, the model also generates the increasing relative average wages observed in the data (see Figure 3.9), 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 3.10 shows the model predicts an increase of relative service prices

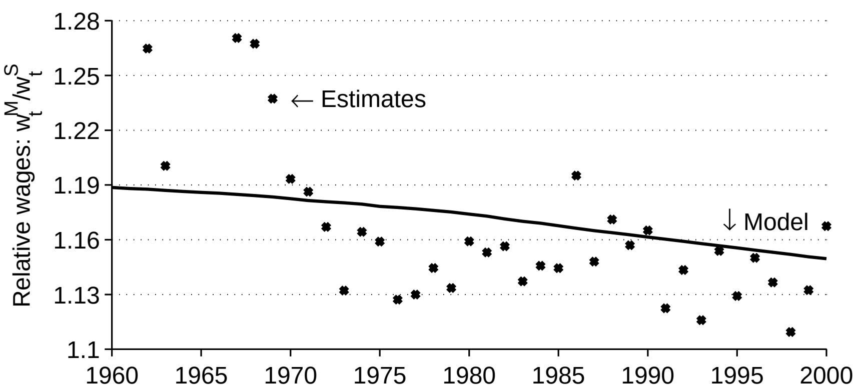


Figure 3.8: Manufacturing over service sector wages

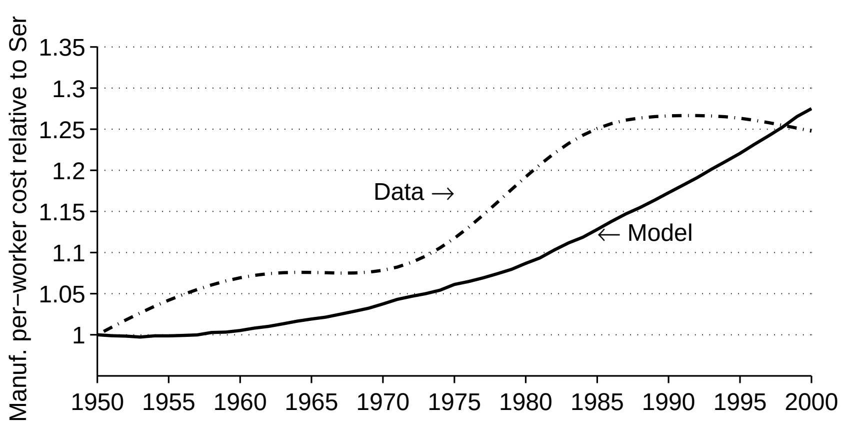


Figure 3.9: Relative average wages (manuf./serv.)

during the period of 190% compared to 120%, obtained from BEA data.

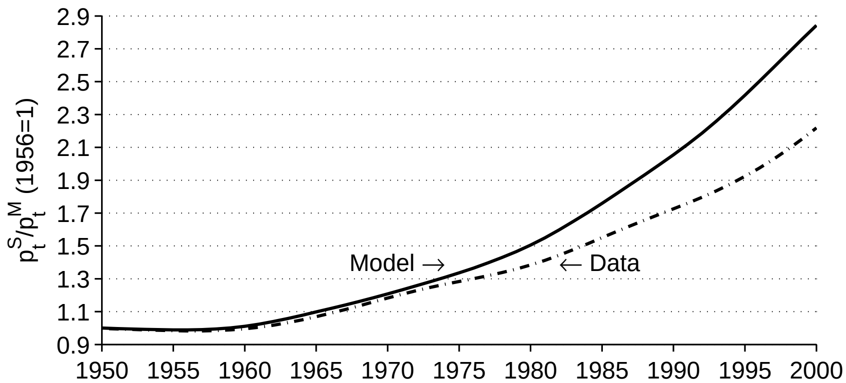


Figure 3.10: Relative prices

3.4.2 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 (3.8), 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 (3.12)

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

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 (3.15) and (3.16) remain unchanged, while (3.18), (3.19), and (3.20) are replaced by:

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

$$\frac{p_t^S C_t^S}{P_t^M C_t^M} = \left[\frac{\gamma}{(1-\gamma)} \right]^{\frac{1}{\phi-1}} \left[\frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \frac{A_t^M}{A_t^S} \right]^{\frac{\phi}{\phi-1}}, \tag{3.19'}$$

$$\frac{p_t^S}{P_t^M} = \frac{\epsilon}{I^{\frac{\epsilon-1}{\epsilon}}} \frac{A_t^M}{A_t^S}, \tag{3.20'}$$

respectively.

Table 3.2 shows the key parameters for this calibration. Notice that I use the same weight 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 3.2: Calibration 2

Parameter	Value	Description	Target
b	2.0	Pareto distrib. shape param.	Table 3.1
γ	0.821	manufactured goods weight	initial $\frac{L^S}{L^M}$
I	4.792	measure of manuf. firms	initial $\frac{\frac{p^S C^S}{P^M C^M}}{\frac{N^S}{N^M}}$

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 3.3. 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 3.4.1). The last row in Table 3.3 shows these results.

Table 3.3: Elasticity of substitution, output and prices in 2000

	$\frac{p^S C^S}{GDP}$	$\frac{p^M C^M}{GDP}$	$\frac{p^M}{p^S}^\star$	$\frac{1}{1-\phi}$
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.

3.4.3 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 3.4.1. 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 3.5 shows the sectoral composition used in calibration, compared to that in Sections 3.4.1 and 3.4.2). Table 3.4 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 3.4.1, 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).

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 in Table 3.7. Figure 3.11 compares data on shares of output and employment

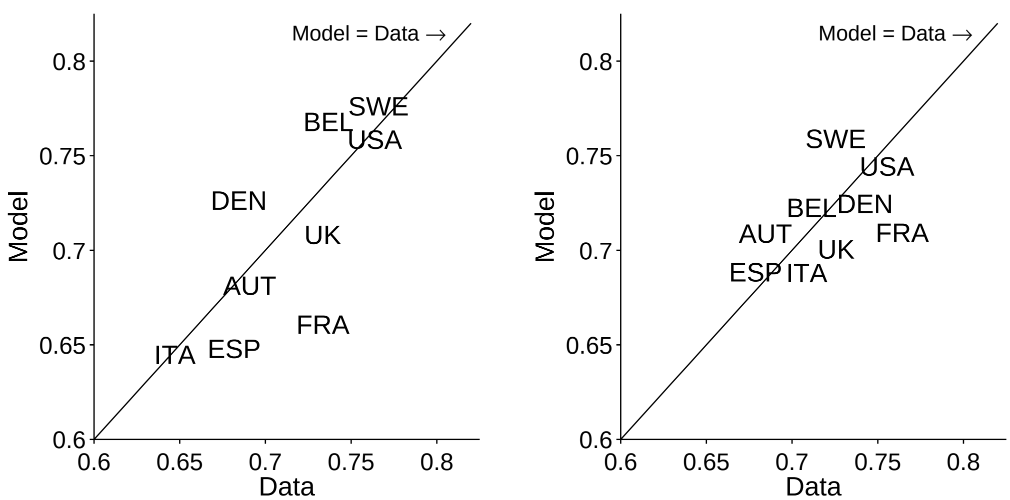
[12]The sample of countries was selected due to data availability for sectoral wages, output, and employment. See Appendix 3.A for details.

Table 3.4: 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	$\frac{\frac{P^S C^S}{P^M C^M}}{\frac{N^S}{N^M}}$, 1970
b	2.1	Pareto distrib. shape param.	distribution of wages*
κ	0.328	bargaining cost	N^M_{1998}
ρ	0.488	union bargaining power	$\frac{w^M_{1998}}{w^S_{1998}}$
ϵ	0.870	inv. manuf. price markup	Bayoumi et al. (2004)
g_{A^M}	($\star$)	manuf. output per worker growth	BEA
g_{A^S}	($\star$)	serv. output per worker growth	BEA

($\star$): For construction details, see Data Description in Appendix 3.C. ($*$): Measured by Gini coefficient of 0.33, see discussion.

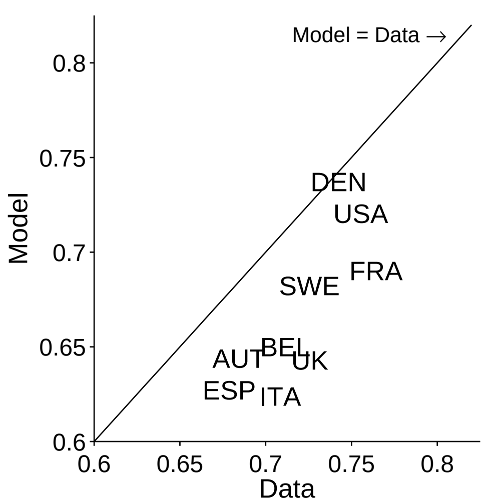
in services in 2000 to the model's predictions. The closer the model points are to the 45-degree line, the better the prediction. It is obvious that the model does a good job of matching structural change after 30 years for the eight European economies.



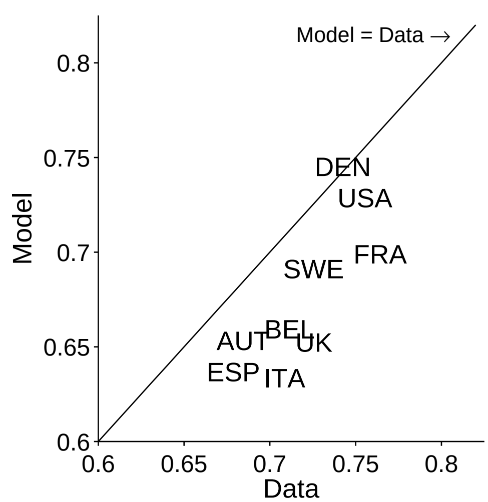
(a) Employment (b) Output

Figure 3.11: 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 3.4.2). 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 3.12a. 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 3.12b 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.



(a) $\phi = -4.26$



(b) $\phi = -10.00$

Figure 3.12: No bargaining case: output

[13]Other parameters in the calibration remain unchanged.

3.5 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 calibrateed 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.

3.A Data description

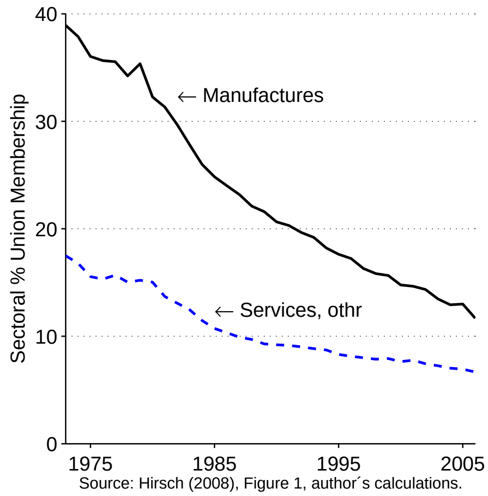
In this section I describe the data used in this paper. I employ two main data sources with one important difference between them. Data for the United States in Calibrations 1 and 2, are obtained from the Bureau of Economic Analysis (BEA), U.S. Bureau of Economic Analysis (2007), as described below. 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 3.5.

Table 3.5: Industrial composition of sectors

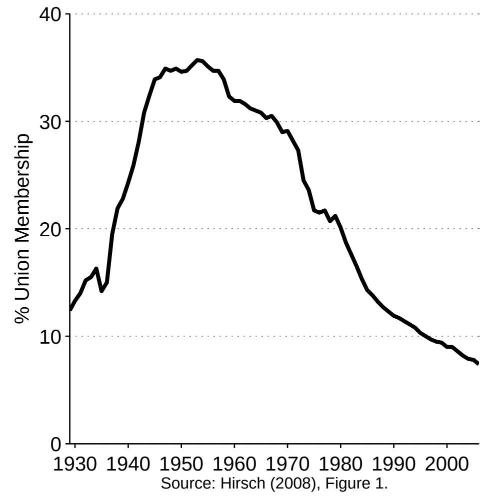
Sector	BEA	OECD
Primary:	• Agriculture, forestry, fishing, and hunting; • Mining	• Agriculture, forestry, fishing, and hunting
Manufacturing:	• Manufacturing	• Mining; • Manufacturing; • Utilities; • Construction
Service:	• Utilities; • Construction; • Wholesale trade; • Retail trade; • Transportation 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 2, 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 3.13a for the 1973-2006 period.



(a) Manufacturing vs. others



(b) Overall economy rates

Figure 3.13: 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 3.13b. For more on the process of de-unionization in the U.S., see Açikgöz and Kaymak (2008).

3.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.

3.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 3.A.1, Table 3.5 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.

3.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.

3.B Relative wages

3.B.1 United States evidence

In this section, I report the estimated coefficients for the wage markup. I follow Angrist and Krueger (1999) (see Chapter 2, Section 2.4 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 3.2b and documented in Table 3.6. Details on the data used to generate these parameters as well as the complete output for the wage regressions are available in Chapter 2.

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 3.6.

3.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

Table 3.6: Estimated wage ratio

Wage ratio ($\overline{w}^M/\overline{w}^S$), 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)*	2002	1.112 (0.012)*
1963	1.201 (0.034)*	1973	1.132 (0.015)*	1983	1.137 (0.014)*	1993	1.116 (0.014)*	2003	1.099 (0.013)*
1964	1.331 (0.033)*	1974	1.164 (0.016)*	1984	1.146 (0.015)*	1994	1.154 (0.015)*	2004	1.094 (0.013)*
1965	1.339 (0.032)*	1975	1.159 (0.016)*	1985	1.144 (0.014)*	1995	1.129 (0.014)*	2005	1.125 (0.014)*
1966	1.309 (0.022)*	1976	1.127 (0.015)*	1986	1.195 (0.015)*	1996	1.15 (0.016)*	2006	1.127 (0.014)*
1967	1.271 (0.025)*	1977	1.13 (0.014)*	1987	1.148 (0.014)*	1997	1.137 (0.015)*	2007	1.092 (0.014)*
1968	1.267 (0.018)*	1978	1.145 (0.013)*	1988	1.171 (0.013)*	1998	1.109 (0.015)*	2008	1.131 (0.014)*
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)*		

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

the labor force, 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 3.7.

3.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 3.A.

Table 3.7: 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 3.5. ($\star$): Calibration 3, see Table 3.5.

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 (3.15) and (3.16), output per worker (N_t^i) in sector i is:

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

Where $\overline{h}_t^i \equiv E\left(h | h \in \mathcal{H}_t^i\right)$ 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 $\overline{h}_t^i$ and, hence, the actual productivity level in the model.

Chapter 4

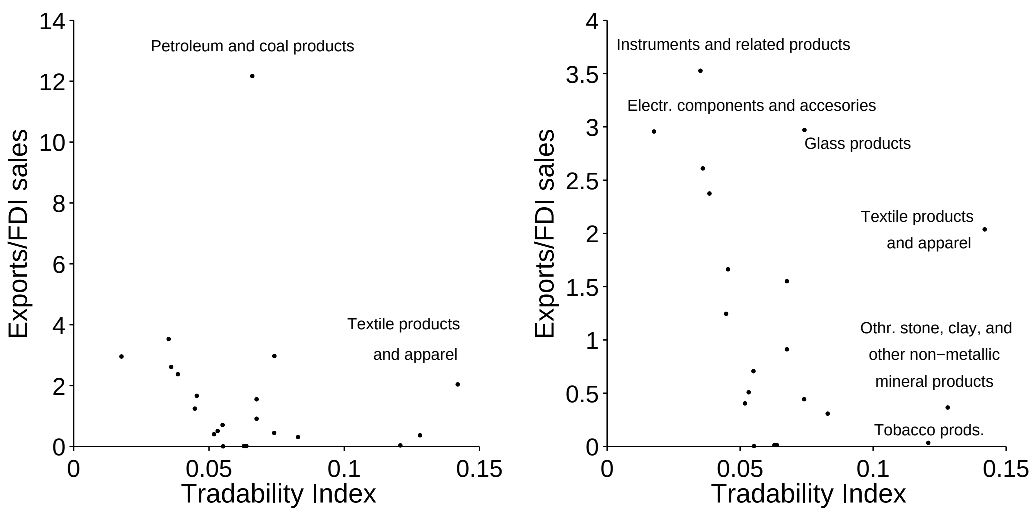
FDI vs. exports: accounting for differences in export-sales intensities

4.1 Introduction

Industry level data shows striking differences in the choice to serve foreign markets through exporting versus through selling goods produced by a foreign affiliate (what we call FDI sales). Only recently has the "new trade theory" literature addressed this issue. Building on Melitz (2003), Helpman et al. (2004) show that models of monopolistic competition can capture firms' choice of foreign market servicing. These authors use reduced-form regression analysis to show that differences in the form of foreign market servicing across sectors can be explained by product tradability (how easy it is to actually trade/ship a product), fixed setup costs and firm productivity dispersion.

In this paper we identify varying aspects of the trade and FDI sale choice (*e.g.*, tradability and home bias) that explain the endogenous (and large) sectoral differences in the choices of exports and FDI sales that Helpman et al. (2004) and others have empirically documented. We derive a general equilibrium model of monopolistic competition where firms choose to service a market through either exports or a foreign affiliate. The model is a multi-country and multi-sector model where, using sectoral data on bilateral trade, FDI sales, employment and costs, we test whether the tradability of goods can capture the observed variations described above. We find that a measure of tradability alone is not enough to determine the ratio of exports to FDI sales.

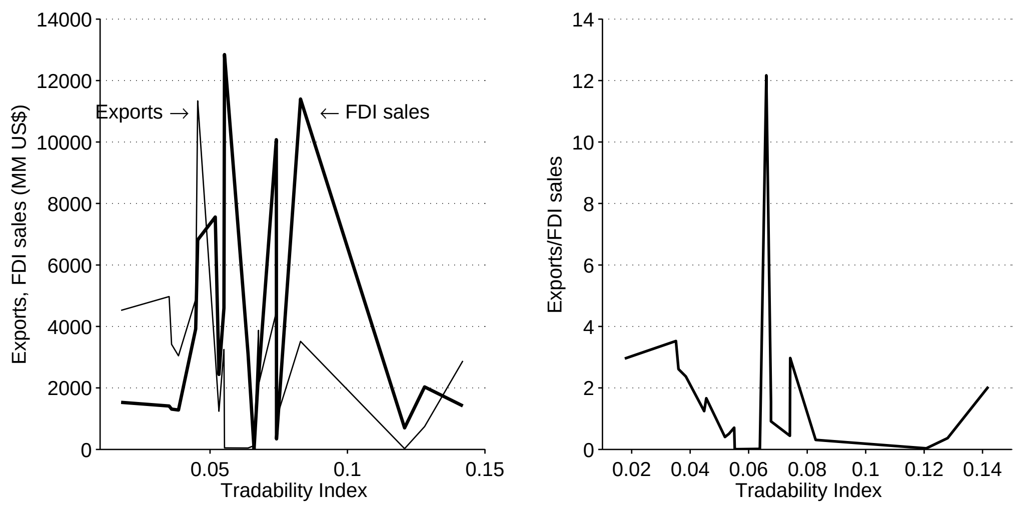
Figure 4.1 shows the relationship between the tradability index we construct (where a higher index value implies the good is less tradable, as explained in Section 4.5) and the ratio of exports to FDI sales. The graph on the right omits the outlier sector of *Petroleum and Coal Products*. It is evident that no strong relationship between the form of service ratio and the tradability index exists. Moreover, Figure 4.2 shows there is no direct relationship between the index and total sector sales.



(a) All sectors (b) w/o outliers

Figure 4.1: Exports / FDI sales vs. tradability index

We argue that by allowing for other dimensions of the model to be sector-specific, we can improve its explanatory power. To do so, we discuss five different variants on a model of monopolistic competition, where we allow for elements such as sector-specific fixed costs, sector-specific firm productivity dispersion, sales taxes, and home product bias in the utility function. We find that sector-specific fixed costs and productivity dispersion are not sufficient to explain the observed differences in exports and FDI sales. However, sector-specific sales taxes on the operations of foreign affiliates and sector-specific home product bias allow us to do so. The latter provides more realistic



(a) MM of dollars

(b) Exports/FDI sales

Figure 4.2: FDI sales and exports

results because the sales tax model requires implausible rates in some sectors of the economy.

The rest of the paper is organized as follows. Section 4.2 presents the background and motivation and discusses the related literature. In section 4.3, we develop the model and characterize the equilibrium of the economy. Comparative statics, discussed in section 4.4, explore the elements of the model that can explain foreign market servicing differences. Section 4.5 describes the data used in the numerical experiments presented in section 4.6. Finally, we draw concluding remarks in section 7.

4.2 FDI and the "new trade theory"

This paper is part of a literature which studies foreign production and foreign market servicing going back to Mundell (1957) and Dunning (1973). In these classical papers, trade and factor mobility (*e.g.*, investment abroad) are studied as alternative forms of foreign market servicing. Having a common starting point, the literature on foreign direct investment diverted into two clearly differentiated streams.

The first branch sought to understand the impact foreign direct investment (FDI) on the host economy rather than on the alternatives of foreign market servicing. Saggi (2002) surveys the impact of FDI-friendly policies and their impact in terms of technology transfer from developed (source) to developing (host) economies, and concludes that at the aggregate level there is a positive impact of FDI on growth of the host economy. Alternatively, Alfaro and Rodriguez-Clare (2004) find no conclusive evidence of the externalities or spillovers of multinationals on local economies; except when the degree of development of the host financial markets is taken into account (see Alfaro et al. (2004) and Alfaro et al. (2009), for example).

Our paper follows the second branch of the literature which is concerned with the choice foreign market servicing. This literature, thoroughly discussed in Markusen (2004) and Brakman and Garretsen (2008), studies foreign direct investment from an industrial organization point of view. Often referred to as "new trade theory," it explores the role of firm characteristics in foreign market servicing choices. While Dunning (1973) was the first to address the importance of ownership, location, and internalization of production processes, Dixit and Stiglitz (1977) are the ones who formalize the behavior of firm's production decisions. Helpman (1984) took the next step by modeling firms whose headquarters are in a different location from that of where production takes place, proposing the first framework for multinational corporations.

More recently, Melitz (2003) extended the monopolistic competition model of Dixit and Stiglitz (1977) to explain the impact of trade on intra-sector reallocations and changes in aggregate productivity. However, his model became more successful in the trade literature, examples of which are Helpman et al. (2004), Chaney (2005; 2006), and Arkolakis (2008). The first of these papers extends Melitz's model to allow active firms to choose between servicing the "local" market only and servicing local and foreign markets, the latter through exports or foreign affiliates, which brings us to our model.

In this paper we discuss the importance of heterogenous firms that compete in a monopolistic competition fashion in explaining the choices between serving foreign markets through exports versus FDI sales. One important assumption we make is that these two options are mutually exclusive. Blonigen (2001) documents this regularity using Japanese data. Moreover, we set up a model where horizontal FDI is the only option available to firms (*i.e.*, the whole production process is carried out through a foreign subsidiary). Although more general frameworks like Markusen (2004) allow for both horizontal and vertical FDI to coexist, we justify our decision on two criteria. The question in our paper is how do firms service foreign markets (and hence how is differing composition across sectors determined) and not how is the production process determined. Hence, in our model firms cannot choose to outsource parts of the production process, but rather choose among different alternatives of (foreign) market servicing. Additionally, Carr et al. (2001) suggests that horizontal FDI is empirically more relevant that the vertical counterpart.

Our paper builds on Helpman et al. (2004), which uses differences in fixed setup costs, as well as marginal and transportation costs to induce different choices among firms.[1] Important features of this model that we discuss later are:

(1) among firms which choose to service the foreign market, the most efficient ones engage in FDI and the least efficient, in exports;

(2) firm level heterogeneity in productivity adds an important dimension to the trade-off between exports and FDI: *ceteris paribus*, sectors with higher dispersion in productivity have lower relative export sales (and higher FDI sales);

(3) when the tradability index (transportation costs in their model) varies between sectors, they find that sectors with high transport costs have lower relative export sales.

4.3 Benchmark model

This is an n-country model of differentiated firms making foreign market servicing decisions. A representative consumer in each country chooses consumption over the goods available in her country. Goods are produce by firms which choose whether to produce domestically and abroad. The latter decision involves choosing between exporting or engaging in FDI operations (*i.e.*, production thorough a foreign subsidiary). In what follows, we discuss the economy in detail.

[1] Nocke and Yeaple (2007) extend the discussion to consider the choice between mergers and acquisitions (M&A) and greenfield FDI, which is outside the scope of this paper.

4.3.1 Consumer's problem

The representative consumer in country i is endowed with L^i units of labor that are inelastically supplied every period and consumes a composite good:

$$C_t^i \leq \left(\int_\omega \left[\alpha^i(\omega) x_t^i(\omega) \right]^\rho d\omega \right)^{\frac{1}{\rho}}.$$

where $x_t^i(\omega)$ is consumption of each differentiated good ω and $\alpha^i(\omega)$ is the good-specific utility weight. The consumer maximizes her inter-temporal utility of consumption:

$$U^i = \sum_{t=0}^{\infty} \beta^t C_t^i;$$

subject to her budget constraint:

$$\int_\omega p_t^i(\omega) x_t^i(\omega) d\omega \leq w_t^i l_t^i + \Pi_t^i; \;\; \forall t,$$

where Π^i are profits of the set Ω^i of monopolistic firms owned by the consumer's country:

$$\Pi_t^i = \int_\omega \pi_t^i(\omega).$$

We make the standard assumption that $\rho \in (0,1)$. This restriction in parameters guarantees that we can aggregate consumption and endowments and solve the problem of a representative consumer in each country.

First order necessary conditions yield the demand for differentiated good $x^i(\omega)$:

$$x^i(\omega) = Y^i \left(\frac{p^i(\omega)}{\alpha^i(\omega)^\rho P^i} \right)^{\frac{1}{\rho-1}}, \tag{4.1}$$

where

$$Y^i = \left(\int_\omega \left[\alpha^i(\omega) x^i(\omega) \right]^\rho d\omega \right)^{\frac{1}{\rho}}, \tag{4.2}$$

$$P^i = \left(\int_\omega \left[\frac{p^i(\omega)}{\alpha^i(\omega)} \right]^{\frac{\rho}{\rho-1}} d\omega \right)^{\frac{\rho-1}{\rho}}, \tag{4.3}$$

are aggregate consumption and prices in country i, respectively. For notational simplicity, we omit t as the equations are the same each period.

4.3.2 Firm's problem

In each country there is a continuum of firms producing differentiated goods. Each firm draws two distinguishing qualities:

(1) productivity level φ, where higher φ implies higher productivity. $\varphi \in (1, \infty)$ is distributed Pareto;

(2) tradability index τ, representing the ease of international trade, where higher τ implies the good is less tradable; $\tau \in (1, \infty)$; the probability of observing τ is $q(\tau)$.

A firm producing good ω is identified by the pair (φ, τ).

Firms that enter the domestic market (d) must pay a fixed entry cost f_e prior to observing their realizations of φ and τ. If they remain in the market, they pay a fixed operational cost f_d. These firms may service foreign markets by choosing between exporting (x) and FDI (m). If they do so, firms have to pay a fixed entry cost which differs for each option of foreign market servicing (f_{ex}, to engage in exports; f_{em}, to engage in multinational operations). Given there is no uncertainty in our model, once a firm enters the market, it will never choose to exit. There is, however, an exogenous firm death rate ($\hat{\delta} \in (0, 1)$) that bounds the value of entering the market.

As in Melitz (2003), the foreign market servicing decision is taken after a firm knows its type (φ, τ). Hence, firms are indifferent between paying a one-time entry cost (f_{ex} or f_{em}) or making per-period payments (δf_{ex} or δf_{em}), where $\delta \equiv (1 - \hat{\delta})\beta$ and β is the time discount factor.[2] For convenience we assume the latter and define:

$$f_x \equiv \delta f_{ex}$$
$$f_m \equiv \delta f_{em}$$

[2]This comes from the fact that the discounted present value of a per-period payment is:

$$f_e = \sum_{t=0}^{\infty} ((1 - \hat{\delta})\beta)^t f = \sum_{t=0}^{\infty} (1 - \delta)^t f = \frac{f}{\delta}.$$

as the per-period fixed costs for exports (x) and multinational operations (m), respectively.

Labor is the only factor of production. The technology is determined by labor input functions that are linear in output

$$\begin{aligned} l &= \frac{y}{\varphi} + f_k, \quad \text{for } k \in \{d, m\}, \\ l &= \frac{y}{\varphi}\tau + f_x, \end{aligned}$$

where in the case of exports, the tradability index is interpreted as an iceberg cost that requires more labor be devoted to production. Marginal production costs and entry costs are paid in labor units.

For simplicity we assume international markets are segmented to preclude arbitrage of goods from occurring. Hence, we exclude the option to reexport and multinational subsidiaries cannot export their production. Hence, firm (φ, τ) maximizes profits in each market independently:

$$\begin{aligned} \pi_d^i(\varphi,\tau) &= p_d^i(\varphi,\tau) y_d^i(\varphi,\tau) - w^i l_d^i(\varphi,\tau), \\ \pi_x^j(\varphi,\tau) &= p_x^j(\varphi,\tau) y_x^j(\varphi,\tau) - w^i l_x^i(\varphi,\tau), \\ \pi_m^j(\varphi,\tau) &= p_m^j(\varphi,\tau) y_m^j(\varphi,\tau) - w^j l_m^j(\varphi,\tau). \end{aligned} \tag{4.4}$$

Firms have market power arising from the fact that they produce differentiates goods. Hence, given Bertrand competition and using the demand functions arising from the consumer's problem, the first order conditions yield pricing rules for goods sold in the domestic and foreign markets under each mode of servicing:

$$\begin{aligned} p_d^i(\varphi,\tau) &\le \frac{w^i}{\rho\varphi}; \quad = \frac{w^i}{\rho\varphi} \quad \text{if} \quad y_d(\varphi,\tau) > 0, \\ p_x^j(\varphi,\tau) &\le \frac{w^i\tau}{\rho\varphi}; \quad = \frac{w^i\tau}{\rho\varphi} \quad \text{if} \quad y_x(\varphi,\tau) > 0, \\ p_m^j(\varphi,\tau) &\le \frac{w^j}{\rho\varphi}; \quad = \frac{w^j}{\rho\varphi} \quad \text{if} \quad y_m(\varphi,\tau) > 0. \end{aligned} \tag{4.5}$$

For a draw of φ and τ, a firm will:

- enter the local market when

$$\pi_d^i(\varphi, \tau) \geq 0;$$

- service a foreign market j through exports when

$$\pi_x^j(\varphi, \tau) \geq \max\{0, \pi_m^j(\varphi, \tau)\};$$

- service a foreign market j through FDI when

$$\pi_m^j(\varphi, \tau) \geq \max\{0, \pi_x^j(\varphi, \tau)\}.$$

4.3.3 Feasibility and market clearing

Given prices $\{P^i\}$, wages $\{w^i\}$, and our assumption on market segmentation, in each country i, good type (φ, τ), and servicing option $k \in \{d, x, m\}$, goods markets clear when:

$$y_k^i = x_k^i.$$

Let Ω_k^i be the set of (φ, τ)-firms in country i that are actively producing for market $k \in \{d, x, m\}$. We assume that all countries have the same distributions for τ and φ. Thus, the labor market clearing condition in country i is:

$$\begin{aligned}
L^i &= \int_{(\varphi,\tau)\in\Omega_d^i} l_d^i(\varphi,\tau) dG(\varphi) dF(\tau) + \int_{(\varphi,\tau)\in\Omega_x^i} l_x^i(\varphi,\tau) dG(\varphi) dF(\tau) \\
&\quad + \sum_j \int_{(\varphi,\tau)\in\Omega_m^j} l_m^i(\varphi,\tau) dG(\varphi) dF(\tau) + M_e f_e \\
&= \int_{(\varphi,\tau)\in\Omega_d^i} \left[\frac{y_d(\varphi,\tau)}{\varphi} + f_d\right] dG(\varphi) dF(\tau) + \int_{(\varphi,\tau)\in\Omega_x^i} \left[\frac{\tau}{\varphi} y_x(\varphi,\tau) + f_x\right] dG(\varphi) dF(\tau) \\
&\quad + \sum_j \int_{(\varphi,\tau)\in\Omega_m^j} \left[\frac{y_m(\varphi,\tau)}{\varphi} + f_m\right] dG(\varphi) dF(\tau) + M_e f_e, \qquad (4.6)
\end{aligned}$$

where M_e is the mass of entrant firms.

4.3.4 Productivity and cutoff functions

The solution to this model can be represented by the aggregate price level $\{P\}$ and three cutoff functions: $\{\varphi_d^*(\tau), \varphi_x^*(\tau), \varphi_m^*(\tau)\}$. The cutoff functions $\varphi_k^*(\tau)$ come from the zero profit conditions for each servicing scheme, given by equations (4.4). Hereafter, for notational simplicity, we write all functions of τ as: $z_\tau(\cdot) \equiv z(\tau;\cdot)$.[3] Notice we also assume that countries are symmetric, which implies prices and other aggregate variables are common across countries.

These cutoff functions segment firms into the different options of production. The segmentation within each tradability type τ, which we formally derive below, is as follows: the lowest productivity group for each τ, upon paying the entry cost and realizing they are unprofitable, chooses not to produce. The firms with middle productivity will only serve the domestic market. The firms with highest productivity choose to serve the foreign market. Among this group of firms, the most productive do so through FDI sales. This is a standard assumption in the literature (see Helpman et al. 2004). The cutoff conditions are depicted in Figure 4.3.

Cutoff equations

Let revenues be $r_{k,\tau}^i(\varphi) \equiv p_{k,\tau}^i(\varphi) y_{k,\tau}^i(\varphi)$, such that firm profits (4.4) become:

$$\begin{aligned} \pi_{d,\tau}^i(\varphi) &= r_{d,\tau}^i(\varphi)(1-\rho) - w^i f_d \\ \pi_{x,\tau}^j(\varphi) &= r_{x,\tau}^j(\varphi)(1-\rho) - w^i f_x \\ \pi_{m,\tau}^j(\varphi) &= r_{m,\tau}^j(\varphi)(1-\rho) - w^j f_m \end{aligned} \tag{4.7}$$

From (4.1), we obtain expressions for firm revenues:

$$\begin{aligned} r_{d,\tau}^i(\varphi) &= R\left(\frac{P\rho\varphi\alpha^i(\varphi,\tau)}{w^i}\right)^{\frac{\rho}{1-\rho}} \\ r_{x,\tau}^j(\varphi) &= R\left(\frac{P\rho\varphi\alpha^j(\varphi,\tau)}{w^i\tau}\right)^{\frac{\rho}{1-\rho}}, \\ r_{m,\tau}^j(\varphi) &= R\left(\frac{P\rho\varphi\alpha^j(\varphi,\tau)}{w^j}\right)^{\frac{\rho}{1-\rho}} \end{aligned} \tag{4.8}$$

[3] This is especially useful when we switch to discrete values for τ later on. Then $\alpha_\tau(\omega) = \alpha(\varphi,\tau)$ is not a function of τ, but identified according to each good ω and corresponding τ.

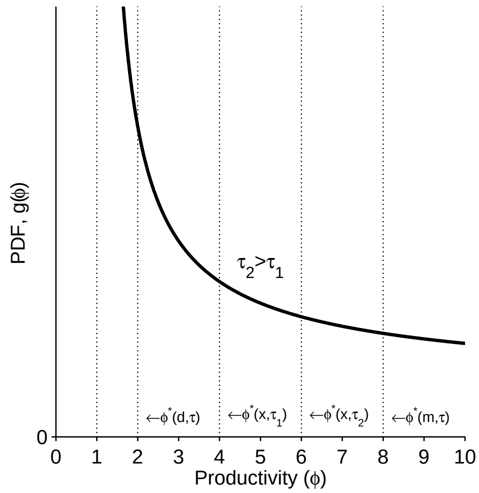


Figure 4.3: Cutoff values

where $R = PY$. To obtain the cutoff equations we substitute (4.8) into (4.7) and set them equal to zero:

$$\begin{aligned} (1-\rho)R\left(\frac{P\rho\varphi\alpha^i(\varphi,\tau)}{w^i}\right)^{\frac{\rho}{1-\rho}} - w^i f_d = 0 \\ (1-\rho)\,R\left(\frac{P\rho\varphi\alpha^j(\varphi,\tau)}{w^i\tau}\right)^{\frac{\rho}{1-\rho}} - w^i f_x = 0 \\ (1-\rho)\,R\left(\frac{P\rho\varphi\alpha^j(\varphi,\tau)}{w^j}\right)^{\frac{\rho}{1-\rho}} - w^j f_m = 0 \end{aligned} \tag{3.7'}$$

so that we have:

$$\begin{aligned} \varphi^*_{d,\tau} &= \left(\frac{w^i f_d}{(1-\rho)R}\right)^{\frac{1-\rho}{\rho}} \frac{w^i}{P\rho\alpha^i(\varphi^*_{d,\tau})}; \\ \varphi^*_{x,\tau} &= \left(\frac{w^i f_x}{(1-\rho)R}\right)^{\frac{1-\rho}{\rho}} \frac{w^i\tau}{P\rho\alpha^j(\varphi^*_{x,\tau})}; \\ \varphi^*_{m,\tau} &= \left(\frac{w^j f_m}{(1-\rho)R}\right)^{\frac{1-\rho}{\rho}} \frac{w^j}{P\rho\alpha^j(\varphi^*_{m,\tau})}. \end{aligned} \tag{4.9}$$

Recall we assume that for each τ, among the firms servicing foreign markets, the least efficient choose to export and the most efficient engage en FDI sales.[4] For this assumption to follow, we must impose conditions on fixed costs, which can be trivially derived from (4.9):

$$f_x > f_d \left(\max\left\{ \tfrac{\tau \alpha_d}{\alpha_x} \right\} \right)^{\frac{\rho}{\rho-1}} \qquad \Leftrightarrow \quad \varphi^*_{d,\tau} < \varphi^*_{x,\tau},\ \forall \tau$$

$$f_m > f_x \tfrac{w^i}{w^j} \left(\tfrac{w^i}{w^j} \max\left\{ \tfrac{\tau \alpha_m}{\alpha_x} \right\} \right)^{\frac{\rho}{1-\rho}} \quad \Leftrightarrow \quad \varphi^*_{x,\tau} < \varphi^*_{m,\tau},\ \forall \tau.$$

We can see in Figure 4.3 that for higher τ (implying the good is less tradable), fewer firms will find it profitable to export and the cutoff $\varphi^*_{x,\tau_1} < \varphi^*_{x,\tau_2}$ for $\tau_2 > \tau_1$.

Entry condition and average productivity

Firms entering the market pay a fixed labor cost f_e. Hence entry is conditional on the discounted present value of profits being greater than or equal to the entry cost. A general expression for the value of entry v_e is

$$\begin{aligned} v_e &= E_\tau \left\{ \mu_{e,\tau} \left(\sum_{t=0}^{\infty} (1-\delta)^t \int_0^\infty \pi_\tau(\varphi) g(\varphi) d\varphi \right) \right\} - w^i f_e \\ &= E_\tau \left\{ \mu_{e,\tau} \left(\frac{1}{\delta} \frac{1}{1 - G(\varphi^*_\tau)} \int_{\varphi^*_\tau}^\infty \pi_\tau(\varphi) g(\varphi) d\varphi \right) \right\} - w^i f_e \\ &= E_\tau \left\{ \mu_{e,\tau} \frac{\overline{\pi}_\tau}{\delta} \right\} - w^i f_e \\ &= \sum_\tau \left\{ q_\tau \mu_{e,\tau} \frac{\overline{\pi}_\tau}{\delta} \right\} - w^i f_e, \end{aligned}$$

where $\mu_{e,\tau} \equiv 1 - G(\varphi^*_{d,\tau})$ is the probability of entry. Profit $\pi_\tau(\varphi)$ is:

$$\pi_\tau(\varphi) = \pi^i_{d,\tau}(\varphi) + \max\{0, \pi^i_{x,\tau}(\varphi), \pi^i_{m,\tau}(\varphi)\},$$

and $\overline{\pi}_\tau$ is the *ex-ante* expected profit for a given τ.

Let $\tilde{\varphi}_{k,\tau}(\varphi^*_{k,\tau})$ be the average productivity of firms with index of tradability τ, con-

[4] This relationship is reported in other countries as well: Buch et al. (2005) and Wagner (2006) find this is the case on German firms; Head and Ries (2003) do so for Japanese firms. We explore variations of this assumption.

ditional on engaging in activity k (domestic production, exports, or FDI sales):

$$\tilde{\varphi}_{k,\tau}(\varphi^*_{k,\tau}) = \left[\frac{1}{1 - G(\varphi^*_{k,\tau})} \int_{\varphi^*_{k,\tau}}^{\infty} \varphi^{\frac{\rho}{1-\rho}} g(\varphi) d\varphi \right]^{\frac{1-\rho}{\rho}}, \tag{4.10}$$

where $\varphi^*_{k,\tau}$ is the productivity of the marginal entrant with τ. For notational simplicity, we will refer to $\tilde{\varphi}_{k,\tau}(\varphi^*_{k,\tau})$ as $\tilde{\varphi}_{k,\tau}$.

Productivity φ is drawn randomly from a Pareto distribution with:

$$\text{CDF:} \quad G(\varphi) = 1 - \left(\tfrac{b}{\varphi}\right)^a, \quad \text{and} \quad \text{PDF:} \quad g(\varphi) = \tfrac{ab^a}{\varphi^{a+1}},$$

where b is the lower support of the distribution and a determines the shape of the distribution. Given this distribution, for a firm engaged in $k \in \{d, x, m\}$ with tradability index τ, (4.10) becomes:

$$\tilde{\varphi}_{k,\tau} = \varphi^*_{k,\tau} \left(\frac{a}{a - \frac{\rho}{1-\rho}} \right)^{\frac{1-\rho}{\rho}}. \tag{4.11}$$

We calculate average profits $\overline{\pi}_{k,\tau}$ given index τ and mode of servicing k by integrating (3.7′) over φ. It is trivial to show that average profit for firms with index τ engaged in market servicing $k \in \{d, x, m\}$ calculated this way is equal to the profits of the average producer with that tradability index servicing market k:

$$\overline{\pi}_{k,\tau} = \pi_{k,\tau}(\tilde{\varphi}_{k,\tau}), \; k \in \{d, x, m\},$$

We can rewrite the equilibrium entry condition as:

$$\begin{aligned} \sum_{\tau} q_{\tau} \left\{ (1 - G(\varphi^*_{d,\tau}))\overline{\pi}_{d,\tau} + (1 - G(\varphi^*_{x,\tau}))\overline{\pi}_{x,\tau} + (1 - G(\varphi^*_{m,\tau}))\overline{\pi}_{m,\tau} \right\} &= \delta w^i f_e \\ (1 - G(\varphi^*_d))\overline{\pi}_d + (1 - G(\varphi^*_m))\overline{\pi}_m + \sum_{\tau} q_{\tau}(1 - G(\varphi^*_{x,\tau}))\overline{\pi}_{x,\tau} &= \delta w^i f_e \end{aligned} \tag{4.12}$$

Equations (4.9) and (4.12) complete the characterization of our equilibrium.

4.4 Qualitative predictions

In this section, we show that we cannot use this "type" of model to reach an unequivocal conclusion about the relationship between the ratio of exports to FDI sales and tradability. Nevertheless, we show that under certain conditions, tradability and home bias can reproduce sectoral patterns observed in the data. We do so by discussing how productivity cutoffs are affected by changes in τ and α. To do so, we identify each sector by the average tradability τ of its firms (which will later be computed from the data). We look at the comparative statics for changes in a good's tradability index within sector τ and between two sectors τ and $\hat{\tau}$, as well as changes in the utility function weights α.

For computational purposes, we assume there is a discrete number S of τ's (*i.e.*, a discrete number of sectors identified by their tradability index). To simplify notation, let $\alpha(\varphi_{k,\tau}, \tau) = \alpha_{k,\tau}$. Let Ψ be the vector of parameters,

$$\Psi = \left\{ \{\tau_1, ...\tau_S\}, \left\{ \{\alpha_{k,\tau_i}, f_{k,\tau_i}\}_{i=1}^{S} \right\}_{k=\{d,x,m\}} \right\}.$$

In equilibrium we can write any function of τ as:

$$z_k(\tau) = z_{k,\tau}(\Psi).$$

From the zero profit condition and (4.9), we have a relationship between average profit and the cutoff productivities such that

$$\pi_k(\varphi^*_{k,\tau}(\Psi)) = 0 \ \Leftrightarrow \ \pi_k(\tilde{\varphi}_{k,\tau}(\Psi)) = f_k h(\varphi^*_{k,\tau}(\Psi)), \ \forall k \in \{d, x, m\},$$

where for each sector τ and mode of servicing k,

$$h(\varphi^*_{k,\tau}(\Psi)) = \left(\frac{\tilde{\varphi}_{k,\tau}(\Psi)}{\varphi^*_{k,\tau}(\Psi)} \right)^{\frac{\rho}{1-\rho}} - 1. \tag{4.13}$$

Additionally, for each τ define

$$j(\varphi^*_{k,\tau}(\Psi)) \equiv [1 - G(\varphi^*_{k,\tau}(\Psi))] h(\varphi^*_{k,\tau}(\Psi)). \tag{4.14}$$

Equation (4.14) decreases with the tradability index, as shown by its partial derivative:

$$\frac{\partial j(\varphi^*_{k,\tau}(\Psi))}{\partial \tau} = -\frac{1}{\varphi^*_{k,\tau}(\Psi)}\left(\frac{\rho}{1-\rho}\right)[1-G(\varphi^*_{k,\tau}(\Psi))][1+h(\varphi^*_{k,\tau}(\Psi))] < 0. \tag{4.15}$$

Using (4.14), we rewrite the entry condition (4.12) as

$$f_d j(\varphi^*_{d,\tau}(\Psi)) + f_m j(\varphi^*_{m,\tau}(\Psi)) + \sum_{\tau} q_\tau f_x j(\varphi^*_{x,\tau}(\Psi)) = \delta f_e, \tag{4.16}$$

and from (4.9) we obtain the cutoff productivity levels for firms producing domestically, exporting, and engaging in FDI sales, respectively:

$$\begin{aligned} \varphi^*_{x,\tau}(\Psi) &= \varphi^*_{d,\tau}(\Psi)\tau\left(\frac{f_x}{f_d}\right)^{\frac{1-\rho}{\rho}}\frac{\alpha^i_{d,\tau}}{\alpha^i_{x,\tau}}, \\ \varphi^*_{x,\hat{\tau}}(\Psi) &= \varphi^*_{d,\tau}(\Psi)\hat{\tau}\left(\frac{f_x}{f_d}\right)^{\frac{1-\rho}{\rho}}\frac{\alpha^i_{d,\tau}}{\alpha^i_{x,\hat{\tau}}}, \\ \varphi^*_{m,\tau}(\Psi) &= \varphi^*_{d,\tau}(\Psi)\left(\frac{w^j f_m}{w^i f_d}\right)^{\frac{1-\rho}{\rho}}\frac{w^j}{w^i}\frac{\alpha^i_{d,\tau}}{\alpha^i_{m,\tau}}. \end{aligned} \tag{4.17}$$

The expressions in (4.17) allow us to analyze the general equilibrium impact of changes in the tradability index (τ) and good weights in the utility function (α), as shown in the next subsections.

4.4.1 Changes in tradability τ

Taking the total derivative of (4.16) with respect to τ, we obtain:

$$\begin{aligned} & f_d j'(\varphi^*_{d,\tau}(\Psi))\frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \tau} + n_m f_m j'(\varphi^*_{m,\tau}(\Psi))\frac{\partial \varphi^*_{m,\tau}(\Psi)}{\partial \tau} \\ & + q_\tau n_x f_x j'(\varphi^*_{x,\tau}(\Psi))\frac{\partial \varphi^*_{x,\tau}(\Psi)}{\partial \tau} + \sum_{\tau' \neq \tau} q_{\tau'}\left[n_x f_x j'(\varphi^*_{x,\tau'}(\Psi))\frac{\partial \varphi^*_{x,\tau'}(\Psi)}{\partial \tau}\right] = 0, \end{aligned} \tag{4.18}$$

where n_k is the measure of firms engaged in productive activity k. We employ this expression as well as the following lemma in the propositions below.

Lemma 1 *When the marginal entrant's good in sector τ becomes harder to trade (i.e.,* *the tradability index τ increases), the cutoff for entry into the domestic market decreases in all sectors,* i.e., $\frac{\partial \varphi^*_{d,\hat{\tau}}(\Psi)}{\partial \tau} < 0, \forall \hat{\tau}$.

Proof From (4.17), we have

$$\begin{aligned}
\frac{\partial \varphi^*_{x,\tau}(\Psi)}{\partial \tau} &= \frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \tau} \frac{\varphi^*_{x,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} + \frac{\varphi^*_{x,\tau}(\Psi)}{\tau} \\
\frac{\partial \varphi^*_{x,\hat{\tau}}(\Psi)}{\partial \tau} &= \frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \tau} \frac{\varphi^*_{x,\hat{\tau}}(\Psi)}{\varphi^*_{d,\tau}(\Psi)}; \quad \forall \hat{\tau} \neq \tau \\
\frac{\partial \varphi^*_{m,\tau}(\Psi)}{\partial \tau} &= \frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \tau} \frac{\varphi^*_{m,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)}
\end{aligned} \tag{4.19}$$

Substituting (4.19) into the total derivative (4.18), we obtain the result:

$$\frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \tau} = -\frac{q_\tau}{\tau} n_x f_x j'(\varphi^*_{x,\tau}(\Psi)) \varphi^*_{x,\tau}(\Psi) \times \cdots \tag{4.20}$$

$$\times \frac{1}{\left(f_d j'(\varphi^*_{d,\tau}(\Psi)) + n_m f_m j'(\varphi^*_{m,\tau}(\Psi)) \frac{\varphi^*_{m,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} + \sum_{\tau'} q_{\tau'} n_x f_x j'(\varphi^*_{x,\tau'}(\Psi)) \frac{\varphi^*_{x,\tau'}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} \right)} < 0.$$

∎

Proposition 2 *The cutoff for exports in a sector is increasing in the sector's tradability:* $\frac{\partial \varphi^*_{x,\tau}(\Psi)}{\partial \tau} > 0$.

Proof The result follows from Lemma 1 and (4.18):

$$\frac{\partial \varphi^*_{x,\tau}(\Psi)}{\partial \tau} = -\frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \tau} \times \cdots$$

$$\times \frac{\left(f_d j'(\varphi^*_{d,\tau}(\Psi)) + n_m f_m j'(\varphi^*_{m,\tau}(\Psi)) \frac{\varphi^*_{m,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} + \sum_{\tau' \neq \tau} q_{\tau'} n_x f_x j'(\varphi^*_{x,\tau'}(\Psi)) \frac{\varphi^*_{x,\tau'}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} \right)}{f_x j'(\varphi^*_{x,\tau}(\Psi))} > 0.$$

∎

Proposition 3 *If the cutoff productivity for domestic market production is highly responsive to changes in the tradability index in sector τ, the marginal FDI-engaged firm's productivity in sector τ increase with τ, and viceversa. In other words,* $\frac{\partial \varphi^*_{m,\tau}(\Psi)}{\partial \tau} < 0$ *if* *and only if the τ-elasticity of the productivity of the domestic marginal entrant in sector τ $\left(\varepsilon_{\varphi_d,\tau} = \frac{\partial\varphi_d^*}{\partial\tau}\frac{\tau}{\varphi_d^*}\right)$ is "low enough."*

Proof Following Proposition 1, substitute (4.19) into (4.18) and use (4.20) to obtain

$$\frac{\partial\varphi_{m,\tau}^*(\Psi)}{\partial\tau} = -\frac{1}{n_m f_m j_m'(\varphi_{x,\tau}^*(\Psi))}\left(\frac{\partial\varphi_{d,\tau}^*(\Psi)}{\partial\tau}\left[f_d j'(\varphi_{d,\tau}^*(\Psi)) + \sum_{\tau'} q_{\tau'} n_x f_x j'(\varphi_{x,\tau'}^*(\Psi))\frac{\varphi_{x,\tau'}^*(\Psi)}{\varphi_{d,\tau}^*(\Psi)}\right] + \frac{\varphi_{x,\tau}^*(\Psi)}{\tau} q_\tau n_x f_x j_x'(\varphi_{x,\tau}^*(\Psi))\right) \lesseqqgtr 0. \tag{4.21}$$

Equation (4.21) is negative when:

$$\varepsilon_{\varphi_d,\tau} \leq \frac{\varphi_{x,\tau}^*(\Psi) q_\tau n_x f_x j_x'(\varphi_{x,\tau}^*(\Psi))}{f_d j'(\varphi_{d,\tau}^*(\Psi))\varphi_{d,\tau}^*(\Psi) + \sum_{\tau'} q_{\tau'} n_x f_x j'(\varphi_{x,\tau'}^*(\Psi))\varphi_{x,\tau'}^*(\Psi)}.$$

The converse follows trivially from above. ∎

From the above propositions, we see that while an increase in tradability decreases exports, exports over FDI sales will only increase when the τ-elasticity of φ_d^* is low enough.

4.4.2 Changes in utility weights

An alternative explanation to the varying ratios of exports/FDI sales are sectoral differences in home bias. For this purpose, take the total derivative of equation (4.16) with respect to $\alpha_{x,\tau}$ to obtain:

$$f_d j'(\varphi_{d,\tau}^*(\Psi))\frac{\partial\varphi_{d,\tau}^*(\Psi)}{\partial\alpha_{x,\tau}} + n_m f_m j'(\varphi_{m,\tau}^*(\Psi))\frac{\partial\varphi_{m,\tau}^*(\Psi)}{\partial\alpha_{x,\tau}} + q_\tau n_x f_x j'(\varphi_{x,\tau}^*(\Psi))\frac{\partial\varphi_{x,\tau}^*(\Psi)}{\partial\alpha_{x,\tau}} + \sum_{\tau'\neq\tau} q_{\tau'}\left[n_x f_x j'(\varphi_{x,\tau'}^*(\Psi))\frac{\partial\varphi_{x,\tau'}^*(\Psi)}{\partial\alpha_{x,\tau}}\right] = 0 \tag{4.22}$$

Additionally, from (4.17) we have partial derivatives for cutoff productivity levels with respect to the same parameter:

$$\begin{aligned}\frac{\partial\varphi^*_{x,\tau}(\Psi)}{\partial\alpha_{x,\tau}} &= \frac{\partial\varphi^*_{d,\tau}(\Psi)}{\partial\alpha_{x,\tau}}\frac{\varphi^*_{x,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} - \frac{\varphi^*_{x,\tau}(\Psi)}{\alpha_{x,\tau}}\\ \frac{\partial\varphi^*_{x,\hat{\tau}}(\Psi)}{\partial\alpha_{x,\tau}} &= \frac{\partial\varphi^*_{d,\tau}(\Psi)}{\partial\alpha_{x,\tau}}\frac{\varphi^*_{x,\hat{\tau}}(\Psi)}{\varphi^*_{d,\tau}(\Psi)}\\ \frac{\partial\varphi^*_{m,\tau}(\Psi)}{\partial\alpha_{x,\tau}} &= \frac{\partial\varphi^*_{d,\tau}(\Psi)}{\partial\alpha_{x,\tau}}\frac{\varphi^*_{m,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)}.\end{aligned} \tag{4.23}$$

We employ 4.23 along with Lemma 2 to derive two important results.

Lemma 2 *When the utility weight $\alpha_{x,\tau}$ in sector τ increases, the productivity of the marginal domestic producer in that sector increases,* i.e.,$\frac{\partial\varphi^*_{d,\tau}(\Psi)}{\partial\alpha_{x,\tau}} > 0$.

Proof Substituting (4.23) into (4.22), we have that

$$\frac{\partial\varphi^*_{d,\tau}(\Psi)}{\partial\alpha_{x,\tau}} = \frac{q_\tau}{\tau} n_x f_x j'(\varphi^*_{x,\tau}(\Psi))\frac{\varphi^*_{x,\tau}(\Psi)}{\alpha_{x,\tau}} \times \cdots$$
$$\times \frac{1}{\left(f_d j'(\varphi^*_{d,\tau}(\Psi)) + n_m f_m j'(\varphi^*_{m,\tau}(\Psi))\frac{\varphi^*_{m,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} + \sum_{\tau'} q_{\tau'} n_x f_x j'(\varphi^*_{x,\tau'}(\Psi))\frac{\varphi^*_{x,\tau'}(\Psi)}{\varphi^*_{d,\tau}(\Psi)}\right)} > 0. \tag{4.24}$$

This means that if consumers' value for consuming a good increases, all other things equal, they demand less of that good and more of others. In the steady state, the aggregate price decreases, there are less firms in the market, and the marginal and average domestic firms must be more productive. ∎

Proposition 4 *The productivity of the marginal exporter in sector τ increases with that sector's home bias,* i.e., $\frac{\partial\varphi^*_{x,\tau}(\Psi)}{\partial\alpha_{x,\tau}} > 0$.

Proof Similarly, substituting (4.23) into (4.22) and using (4.24),

$$\frac{\partial \varphi^*_{x,\tau}(\Psi)}{\partial \alpha_{x,\tau}} = \frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \alpha_{x,\tau}} \frac{1}{f_x j'(\varphi^*_{x,\tau}(\Psi))} \Bigg(f_d j'(\varphi^*_{d,\tau}(\Psi)) + n_m f_m j'(\varphi^*_{m,\tau}(\Psi)) \frac{\varphi^*_{m,\tau}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} + \sum_{\tau' \neq \tau} q_{\tau'} n_x f_x j'(\varphi^*_{x,\tau'}(\Psi)) \frac{\varphi^*_{x,\tau'}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} \Bigg) > 0. \tag{4.25}$$

As before, when $\alpha_{x,\tau}$ increases, the marginal and average exporters in sector τ must be more productive. ∎

Proposition 5 *If the cutoff productivity for domestic market production of a good is very responsive to changes in the valuation (weight) of that good, the marginal FDI-engaged firm's productivity in sector τ decrease with α. In other words, $\frac{\partial \varphi^*_{m,\tau}(\Psi)}{\partial \alpha_{x,\tau}} < 0$ if and only if the α-elasticity of the productivity of the domestic marginal entrant in sector τ $\left(\varepsilon_{\varphi_d,\alpha} = \frac{\partial \varphi^*_d}{\partial \alpha} \frac{\alpha}{\varphi^*_d}\right)$ is "high enough."*

Proof As in Proposition 3, we substitute (4.23) into (4.22) and use (4.24) to obtain

$$\frac{\partial \varphi^*_{m,\tau}(\Psi)}{\partial \alpha_{x,\tau}} = -\frac{1}{n_m f_m j'_m(\varphi^*_{x,\tau}(\Psi))} \Bigg(\frac{\partial \varphi^*_{d,\tau}(\Psi)}{\partial \alpha_{x,\tau}} \Bigg[f_d j'(\varphi^*_{d,\tau}(\Psi)) + \sum_{\tau'} q_{\tau'} n_x f_x j'(\varphi^*_{x,\tau'}(\Psi)) \frac{\varphi^*_{x,\tau'}(\Psi)}{\varphi^*_{d,\tau}(\Psi)} \Bigg] - \frac{\varphi^*_{x,\tau}(\Psi)}{\alpha_{x,\tau}} q_\tau n_x f_x j'_x(\varphi^*_{x,\tau}(\Psi)) \Bigg) \lesseqqgtr 0, \tag{4.26}$$

Then, (4.26) is negative when

$$\varepsilon_{\varphi_d,\alpha_{x,\tau}} \geq \frac{\varphi^*_{x,\tau}(\Psi) q_\tau n_x f_x j'_x(\varphi^*_{x,\tau}(\Psi))}{f_d j'(\varphi^*_{d,\tau}(\Psi)) \varphi^*_{d,\tau}(\Psi) + \sum_{\tau'} q_{\tau'} n_x f_x j'(\varphi^*_{x,\tau'}(\Psi)) \varphi^*_{x,\tau'}(\Psi)}.$$

The converse follows trivially from above. ∎

In this case, we show that while an increase in home bias decreases exports, exports/FDI sales only increases when the τ-elasticity of φ^*_d is high enough.

4.5 Data

In this paper we test a simplified two-country version of the model presented in sections 4.3 and 4.4. To do so, we require multi-sector data in four categories: (1) bilateral trade; (2) bilateral FDI sales; (3) total employment and non-production labor, and (4) indices of transportation costs. All data is in SIC (rev 1987) format for the United States and Canada in 1997. There are two reasons we choose this year. The first one is the discontinuity in industrial classification systems: the FDI sales data was recorded in SIC prior to 1999, and in NAICS format thereafter. The other reason is that 1997 provided data for the largest number of sectors. Since the model can be treated as static, there is no need for multiple years. We organize the industry-level data into the 20 sectors presented in Table 4.1. We describe the data below.[5]

4.5.1 Bilateral international trade

We use import and export data from Feenstra et al. (2002) for the U.S. and Canada for 1997. The import data used is the custom value of imports (millions of U.S. dollars) and is used to weight tariff and freight data (see below). The export data we use, also in millions of U.S. dollars, is the value of exports from the U.S. to Canada.

4.5.2 Bilateral FDI sales

The FDI sales data used comes from the U.S. Bureau of Economic Analysis (2006). We use data on sales by all foreign affiliates by sector as well as country. In particular, we look at U.S. affiliates operating in Canada. According to the BEA, a foreign affiliate is any foreign business in which there is a direct investor from the U.S. owning or controlling at least 10% of voting securities or the equivalent. This definition indistinctly includes mergers and acquisitions as well as greenfield investment.

4.5.3 Employment

We use total employment by sector as well as non-production workers by sector from the 1997 Economic Census of Manufacturing published by the U.S. Census Bureau (2001).

[5] More details are available from the authors.

The latter is constructed from the reported data such that: non-production labor equals total employment minus production workers.

Of the 20 sectors for which we have data on exports and FDI sales, we only have employment for 15. The excluded sectors are: Instruments and Related Products; Construction, Mining, and Materials Handling Machinery; Other Electrical Equipment, Appliances, and Components; Other Petroleum and Coal Products; and Other Chemicals and Allied Products (see Table 4.1).

4.5.4 Tradability index

In our model, we use data on freight costs and tariffs to construct a tradability index. This data is collected by Schott (nd) in SIC rev. 1987 format according to year and sector. The tariff rates are import-weighted, implicit averages, calculated for each year as:

$$\text{tariff} = \frac{\text{duties}}{\text{customs value}}. \tag{4.27}$$

The freight rates are also import-weighted for each year as:

$$\text{freight} = 1 - \frac{\text{cost insurance freight (cif) imports}}{\text{free on board (fob) imports}}. \tag{4.28}$$

Thus, the *tradability index* τ is defined by:

$$\tau \equiv (1 + \text{freight})(1 + \text{tariff}), \tag{4.29}$$

where a higher index implies the good is less tradable. We calculate these indices by sectors according to the concordance described in Table 4.1 (through import-weighting).

4.6 Numerical experiments

In this section we present five variations of our model in an attempt to match the observed ratio of exports to FDI sales for Canada and the U.S. in 1997 for 20 sectors. Recall that we identify sectors by their average tradability τ as constructed from the data. Moreover, we assume the marginal exporter in each sector has that τ. Alternative approaches to sector classification can be considered however, they are outside of the

Table 4.1: Industry level data

Industry	SIC (Rev.1987) codes	τ	Exports	FDI Sales	Total U.S. Employ.	Non-prod. Workers
Grain Mill and Bakery Products	2041+2051+2053	1.0638	45	3,106	357,543	128,286
Other Food and Kindred Products	20-(2041+2051+2053+2082)	1.0741	4,467	10,075	1,109,413	226,363
Tobacco Products	21	1.1208	24	698	33,594	9,153
Textile Products and Apparel	22+23	1.1420	2,881	1,414	1,338,136	224,379
Lumber, Wood, Furniture, and Fixtures	24+25	1.0550	3,252	4,600	570,034	93,809
Paper and Allied Products	26	1.0519	3,054	7,560	574,274	134,178
Chemical Products, nec	2819+2869+2879+2899	1.0676	3,874	2,497	882,645	370,493
Soap, Cleaners, and Toilet Goods	2841+2842	1.0532	1,240	2,438	126,446	48,692
Other Chemicals and Allied Products	28-(2813+2819+2821+282 - (2869+2879+2899+284 -(2842+2879)	1.0829	3,514	11,399	nr	nr
Petroleum and Coal Products, nec	2999	1.0660	122	10	107,625	36,071
Other Petroleum and Coal Products	29-2911-2999	1.0552	49	12,844	nr	nr
Rubber Products	301+302+305+306	1.0676	2,104	2,306	202,353	41,081
Glass Products	321+322+323	1.0742	1,013	341	128,565	23,514
Other Stone, Clay, and Other Nonmetallic Mineral Products	32-(321+322+323)	1.1280	744	2,035	372,906	89,059
Primary and Fabricated Metals	33+34	1.0455	11,337	6,815	2,368,857	562,252
Construction, Mining, and Materials Handling Machinery	353	1.0385	3,046	1,283	nr	nr
Household Audio and Video, and Communications Equipment	365+366	1.0360	3,417	1,309	294,865	159,552
Electronic Components and Accessories	367	1.0176	4,523	1,530	593,802	161,529
Other Electrical Equipment, Appliances, and Components	36-363-365-366-367-369	1.0448	4,881	3,921	nr	nr
Instruments and Related Products	38	1.0351	4,973	1,410	nr	nr

Exports and FDI sales in Millions of U.S. Dollars.
Employment in thousands.
nr: Data not reported.
Data source: See section 4.5.

scope of this paper.

We interpret the utility function weights (α) as home-product bias, *i.e.*, taste differences for goods produced at home (by domestic and foreign multinational firms) versus abroad (imported). We normalize $\alpha^i(\hat{\varphi}^i_{d,\tau},\tau) = \alpha^i(\hat{\varphi}^j_{m,\tau},\tau) = 1$, where $\hat{\varphi}^i_{d,\tau}$ is the productivity of firms producing domestically in i and $\hat{\varphi}^j_{m,\tau}$ that of foreign subsidiaries producing in i. Finally, we assume the two countries are symmetric for computational simplicity.

The mass of operating firms in autarky

In the case of autarky, it is trivial to calculate the (endogenously determined) mass M of operating firms. The tradability index τ is not relevant here, so we can simplify notation. From (4.1) we have that for any two firms with productivity φ and $\tilde{\varphi}$:

$$\frac{x(\varphi)}{x(\tilde{\varphi})} = \left(\frac{p(\varphi)}{p(\tilde{\varphi})}\right)^{\frac{1}{\rho-1}} = \left(\frac{\tilde{\varphi}}{\varphi}\right)^{\frac{1}{\rho-1}}. \tag{4.30}$$

We can use the above to re-write (4.2):

$$\begin{aligned}
Y^i &= \left(\int_{\varphi} M x^i(\varphi)^{\rho} d\varphi\right)^{\frac{1}{\rho}} \\
&= M^{\frac{1}{\rho}} \left(\int_{\varphi} x^i(\tilde{\varphi})^{\rho} \left(\frac{\tilde{\varphi}}{\varphi}\right)^{\frac{\rho}{\rho-1}} d\varphi\right)^{\frac{1}{\rho}} \\
&= M^{\frac{1}{\rho}} x(\tilde{\varphi}) \left(\frac{1}{\tilde{\varphi}}\right)^{\frac{1}{1-\rho}} \left(\int_{\varphi} (\varphi)^{\frac{\rho}{1-\rho}} d\varphi\right)^{\frac{1}{\rho}} \\
&= M^{\frac{1}{\rho}} x(\tilde{\varphi}) = M^{\frac{1}{\rho}} Y \left(\frac{p(\tilde{\varphi})}{P}\right)^{\frac{1}{\rho-1}} \\
\Rightarrow M &= \left(\frac{p(\tilde{\varphi})}{P}\right)^{\frac{\rho}{1-\rho}}.
\end{aligned} \tag{4.31}$$

Hence, M is the autarky mass of operating firms in any given country.

The mass of operating firms in the open economy

We define the mass of domestically operating firms as in (4.31). This comes from the fact that the most inefficient active firm in all sectors τ is the same (and given by (4.9)). Thus, the mass of firms in each sector τ is:

$$M_\tau = q_\tau M. \tag{4.31a}$$

Additionally, the mass of firms within each τ is:

$$M_{x,\tau} = \frac{1-G(\varphi^*_{x,\tau})}{1-G(\varphi^*_{d,\tau})} M_\tau = \mu_{x,\tau} M_\tau,$$
$$M_{m,\tau} = \frac{1-G(\varphi^*_{m,\tau})}{1-G(\varphi^*_{d,\tau})} M_\tau = \mu_{m,\tau} M_\tau.$$

$\mu_{k,\tau}$ is the probability of engaging in foreign market servicing $k \in \{x, m\}$ in sector τ, conditional on being an active firm. The first expression is the measure of firms servicing foreign markets via exports and the second, that of FDI conditional on operating in sector τ. Adding the three expressions above, we get:

$$\mathcal{M}_\tau = M_\tau + n\left(M_{x,\tau} + M_{m,\tau}\right), \tag{4.31b}$$
$$\mathcal{M} = \sum_\tau \mathcal{M}_\tau; \tag{4.31c}$$

where n is the number of countries in the world. Equation (4.31b) is the total measure of firms operating in sector τ and (4.31c) is the total measure of firms operating. The symmetry assumption across countries implies this is the total number of firms a country's representative consumer owns.

Given the definitions above, we write an expression similar to (4.6) which indicates employment in each sector τ:

$$L^i_\tau = f_e M_{e,\tau} + \left[f_d + n(\mu_{x,\tau} f_x + \mu_{m,\tau} f_m)\right] M_\tau$$

so that $L^i = \sum_\tau L^i_\tau$ is aggregate labor. Since aggregate payments to production workers must be equal to the difference between aggregate revenue and profits, and normalizing wages to 1, production labor $L_p = R - \Pi$. Additionally, market clearing conditions imply that labor devoted to pay entry costs is $L_e = M_e f_e$. In a steady state equilibrium, firm entry and exit are equal, *i.e.*, $(1 - G(\omega^*))M_e = \delta M$. Hence the free entry condition implies:

$$L_e = M_e f_e = \frac{\delta M}{(1 - G(\omega^*))} f_e = M\bar{\pi} = \Pi$$

Together, these conditions imply aggregate revenues $R = L_p + \Pi = L_p + L_e = L$. This condition completes our system of equations.

Ratio of exports to FDI sales

To calculate the ratio of exports to FDI sales, we construct total sector sales in the model. We fix the probability q_τ of being in sector τ as the fraction of that sector's total exports and FDI sales over total sales for the 20 sectors, as found in the data:

$$q_\tau = \frac{\text{FDI sales}_\tau + \text{exports}_\tau}{\sum_s (\text{FDI sales}_s + \text{exports}_s)}.$$

Additionally, we choose the fixed costs of production for each sector, to match the measure of firms that operate in each sector and mode of servicing. To see this, consider the measure of firms exporting in sector τ:

$$\begin{aligned} M_{x,\tau} &= \frac{1 - G(\varphi^*_{x,\tau})}{1 - G(\varphi^*_d)} q_\tau M \\ &= \left(\frac{f_d}{f_x}\right)^{a\left(\frac{1-\rho}{\rho}\right)} q_\tau \left(\frac{\alpha_{x,\tau}}{\tau}\right)^a M \\ \Rightarrow \frac{M_{x,\tau}}{M} &= \left(\frac{f_d}{f_x}\right)^{a\left(\frac{1-\rho}{\rho}\right)} q_\tau \left(\frac{\alpha_{x,\tau}}{\tau}\right)^a \end{aligned}$$

which relies only on parameters.

The ratio of aggregate sector exports to FDI sales come from the expression above and (4.8):

$$
\begin{aligned}
\frac{\text{exports}_\tau}{\text{FDI sales}_\tau} &= \frac{r^j_{x,\tau}(\tilde{\varphi}_{x,\tau})}{r^j_{m,\tau}(\tilde{\varphi}_{m,\tau})}\frac{M_{x,\tau}}{M_{m,\tau}} \\
&= \frac{R\left(\frac{P\rho\tilde{\varphi}_{x,\tau}\alpha_{x,\tau}}{w^i\tau}\right)^{\frac{\rho}{1-\rho}}}{R\left(\frac{P\rho\tilde{\varphi}_{m,\tau}}{w^j}\right)^{\frac{\rho}{1-\rho}}}\frac{(1-G(\varphi^*_{x,\tau}))q_\tau M}{(1-G(\varphi^*_{m,\tau}))q_\tau M} \\
&= \left(\frac{\varphi^*_{x,\tau}}{\varphi^*_{m,\tau}}\right)^{\frac{\rho}{1-\rho}-a}\left(\frac{\alpha_{x,\tau}}{\tau}\right)^{\frac{\rho}{1-\rho}} \\
&= \left(\frac{f_{x,\tau}}{f_{m,\tau}}\right)^{1-a\frac{1-\rho}{\rho}}\left(\frac{\alpha_{x,\tau}}{\tau}\right)^{a}. \qquad (4.32)
\end{aligned}
$$

4.6.1 Benchmark model: common fixed costs, $\alpha_\tau = 1$

In the benchmark model, the fixed costs are assumed to be county-specific (as opposed to sector-specific). All utility weights are set equal to one. We use the parameters shown in Table 4.2 and τ from Table 4.1, as well as q_τ described in section 4.5. Figure 4.4, shows this version of the model grossly missed the observed ratio of exports to FDI sales.

Table 4.2: Parameters for baseline model

Parameter	Value	Description
ρ	0.5	utility function parameter
α_τ	1	utility weights
w^h	1	home country's wage
w^f	1	foreign country's wage
L	65,000	labor endowment
f_e	65	fixed entry cost
f_d	1.3	fixed domestic cost
f_x	1.5	fixed export cost
f_m	2.2	fixed FDI cost
$\hat{\delta}$	0.03	death rate of firms
S	20	# sectors in the economy
a	2	shape parameter Pareto distrib.
b	1	lower support Pareto distrib.

All labor units are in thousands.
Targets are described in the discussion.

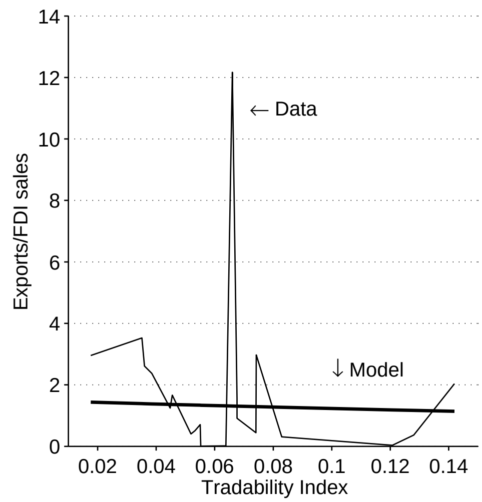


Figure 4.4: Estimated vs. actual exports/FDI sales: benchmark model

4.6.2 Sector-specific fixed costs, $\alpha_\tau = 1$

In this specification, each sector has different fixed costs. We modify our assumptions on the fixed costs from the benchmark model to satisfy the following conditions:

$$f_{x,\tau} > f_d \left(\frac{\tau}{\alpha_{x,\tau}}\right)^{\frac{\rho}{\rho-1}} \quad \Leftrightarrow \quad \varphi^*_{d,\tau} < \varphi^*_{x,\tau},\ \forall\tau$$
$$f_{m,\tau} > f_{x,\tau}\frac{w^i}{w^j}\left(\frac{w^i}{w^j}\frac{\tau}{\alpha_{x,\tau}}\right)^{\frac{\rho}{1-\rho}} \quad \Leftrightarrow \quad \varphi^*_{x,\tau} < \varphi^*_{m,\tau},\ \forall\tau;$$

to be consistent with empirical observations reported in Helpman et al. (2004).

We determine $f_{x,\tau}$ according to the following rule:

$$f_{x,\tau} = f_d \tau^{\frac{\rho}{\rho-1}+2},$$

which satisfies the first restriction. Finally, we choose $f_{m,\tau}$ to match exports to FDI sales data, provided this does not violate the rule above. All other parameters are as in Table 4.2. Under these assumptions, the marginal producers for exports and FDI-sales

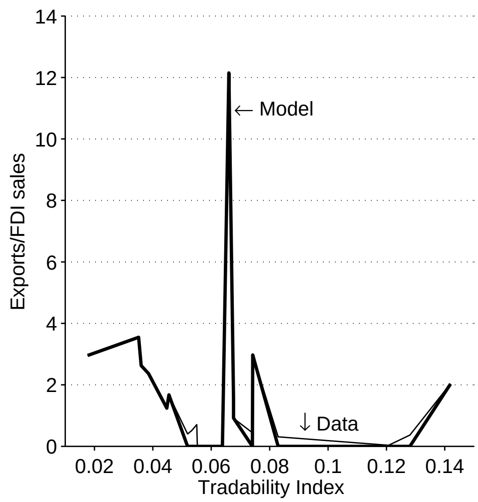


Figure 4.5: Estimated vs. actual exports/FDI sales with sector-specific fixed costs

are:

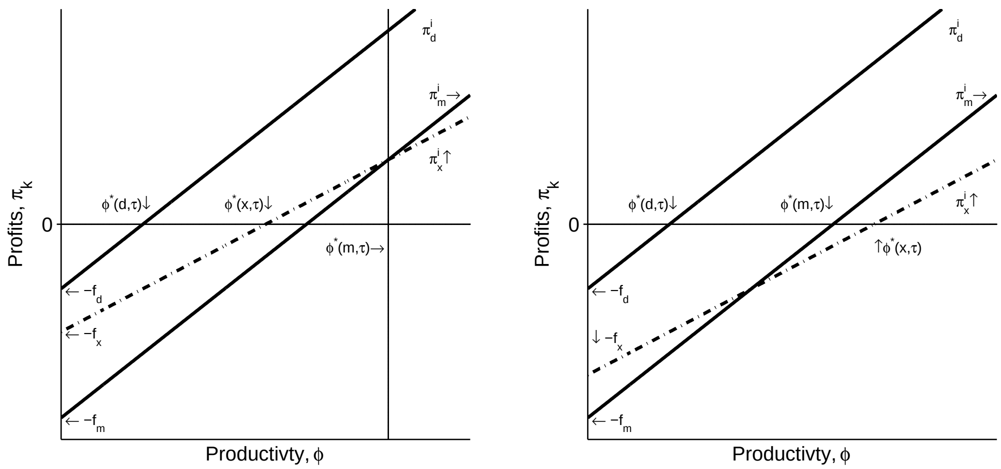
$$\varphi^*_{x,\tau} = \left(\frac{w^i f_{x,\tau}}{(1-\rho)R}\right)^{\frac{1-\rho}{\rho}} \frac{w^i \tau}{P\rho}$$

$$\varphi^*_{m,\tau} = \left(\frac{w^j f_{m,\tau}}{(1-\rho)R}\right)^{\frac{1-\rho}{\rho}} \frac{w^j}{P\rho} \tag{4.33}$$

and the entry condition (4.12) becomes:

$$(1 - G(\varphi^*_d))\overline{\pi}_d + \sum_\tau q_\tau \left\{(1 - G(\varphi^*_{m,\tau}))\overline{\pi}_{m,\tau} + (1 - G(\varphi^*_{x,\tau}))\overline{\pi}_{x,\tau}\right\} = \delta w^i f_e. \tag{4.34}$$

As shown in Figure 4.5, the model fails to match the observed data for some sectors. From equation (4.32), it is trivial to see that in this variant of the model, calibrating fixed costs does not suffice to match the data. This is because f_m has to be so small that there is no incentive to export, *i.e.*, we would violate $\varphi^*_{x,\tau} < \varphi^*_{m,\tau}$ (see the right panel in Figure 4.6).



(a) Exports and FDI sales

(b) FDI sales only

Figure 4.6: Cutoffs with sales taxes

4.6.3 Sector-specific productivity dispersion, $\alpha_\tau = 1$

In this variant of the model, we test the claim from Helpman et al. (2004) that there is a high cross-sectoral relationship between productivity dispersion and firms' choices of foreign market servicing. We allow for the productivity distributions to be sector-specific and we set $\alpha_\tau = 1$. Specifically, we allow for a, the shape parameter of the Pareto distribution (see Section 4.3) to vary among sectors. Moreover, sectoral differences are the same across countries, in line with our assumption of symmetry.

Equation (4.11) requires the following restriction on parameters:

$$\frac{\rho}{1-\rho} - a_\tau < 0, \quad \forall \tau. \tag{4.35}$$

Additionally, from (4.32), recall the equation for the export-to-FDI sales ratio when $\alpha_\tau = 1$ is:

$$\frac{\text{exports}_\tau}{\text{FDI sales}_\tau} = \left(\frac{f_{x,\tau}}{f_{m,\tau}}\right)^{1-a_\tau \frac{1-\rho}{\rho}} \left(\frac{1}{\tau}\right)^{a_\tau},$$

and the fact that

$$f_m > f_x \frac{w^i}{w^j} \left(\frac{w^i}{w^j} \tau \right)^{\frac{\rho}{1-\rho}}$$

is needed for consistency with empirical observations of firm productivity cutoffs.

For the limit case where the above expression is satisfied with equality, (4.32) reduces to:

$$\frac{\text{exports}_\tau}{\text{FDI sales}_\tau} = \tau^{\frac{\rho}{\rho-1}}.$$

where we applied symmetry across countries. From the data we have $\tau > 1$ so we can see that:

(1) for $\rho < 1$, we are only able to match those sectors with lower exports than FDI sales: $\frac{\text{exports}_\tau}{\text{FDI sales}_\tau} < \tau^{\frac{\rho}{\rho-1}} < 1$;

(2) for $\rho > 1$, we are only able to match those sectors with higher exports than FDI sales: $\frac{\text{exports}_\tau}{\text{FDI sales}_\tau} > \tau^{\frac{\rho}{\rho-1}} > 1$.

Hence, it is evident that under the assumptions made, this variant will fail to replicate the intra-sectoral variability in the exports-to-FDI sales ratio as observer in the data.

In the case where $f_m > f_x \frac{w^i}{w^j} \left(\frac{w^i}{w^j} \tau \right)^{\frac{\rho}{1-\rho}}$, under certain parameters could we replicated the data observed. Notice that this inequality implies:

$$\frac{\text{exports}_\tau}{\text{FDI sales}_\tau} = \left(\frac{f_x}{f_m} \right)^{1-a\frac{1-\rho}{\rho}} \tau^{-a} > \tau^{\frac{\rho}{\rho-1}}. \tag{4.36}$$

With $\rho < 1$ as we assume, $\tau^{\frac{\rho}{\rho-1}} < 1$, such that the ratio of exports to FDI sales could be smaller or larger than 1. However, parameter restrictions would not allow to accommodate for the large intra-sectoral variation.

4.6.4 Sector-specific tax on multinational sales, $\alpha_\tau = 1$

This variant of the model is one of the two cases where we are able to match the data, as depicted in Figure 4.7. We allow for sector-specific sales taxes on multinational operations, along with sector-specific fixed costs (to satisfy $\varphi^*_{x,\tau} < \varphi^*_{m,\tau}$). In this case,

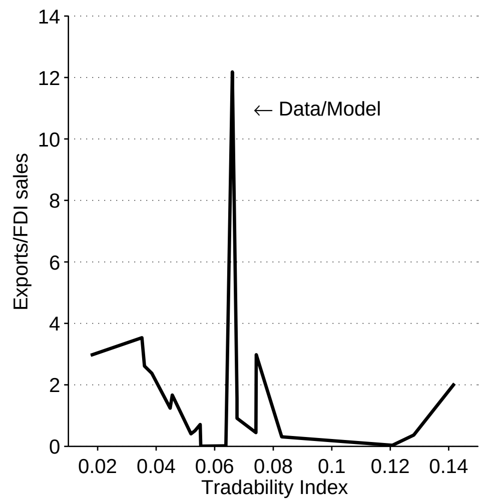


Figure 4.7: Estimated vs. actual exports/FDI sales with sector-specific fixed taxes/fixed costs

the profits of the multinational firm become:

$$\pi^j_{m,\tau}(\varphi) = \sigma_\tau p^j_{m,\tau}(\varphi) y^j_{m,\tau}(\varphi) - w^j l^j_{m,\tau}(\varphi),$$

where $\sigma_\tau - 1$ is the sales tax, when $\sigma_\tau < 1$, or subsidy, when $\sigma_\tau > 1$. We leave other goods untaxed for computational simplicity and because what matters are sales taxes in a sector relative to other sectors. The price multinational firms charge becomes:

$$p_{m,\tau} = \frac{w^j}{\rho \sigma_\tau \varphi_{m,\tau}}.$$

and other price equations remain unchanged. The zero profit condition for firms engaged in multinational operations yields:

$$\varphi^*_{m,\tau} = \left(\frac{w^j f_m}{(1-\rho)R} \right)^{\frac{1-\rho}{\rho}} \frac{w^j}{P\rho} \sigma_\tau^{-\frac{1}{\rho}}$$

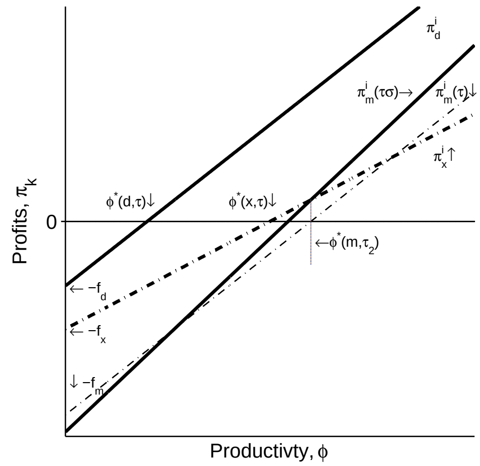


Figure 4.8: Cutoffs with sector-specific fixed taxes/fixed costs

As before, we can write the ratio of exports to FDI sales as:

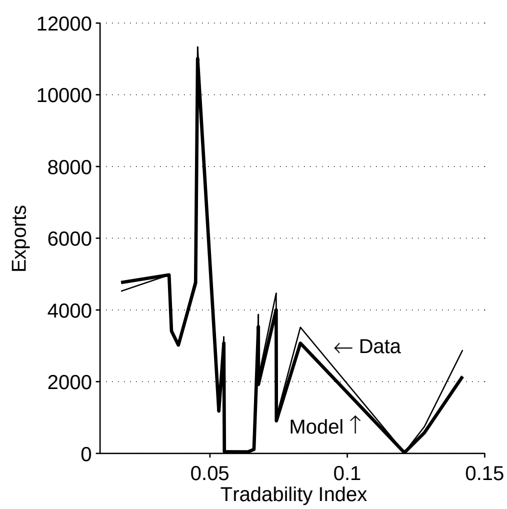
$$\frac{\text{exports}_\tau}{\text{FDI sales}_\tau} = \left(\frac{f_{x,\tau}}{f_{m,\tau}}\right)^{1-a\frac{1-\rho}{\rho}} \left(\sigma_\tau^{\frac{1}{\rho}}\tau\right)^{-a}. \tag{4.37}$$

In Table 4.3 we show the calibrated sales taxes for each sector. Notice that in order to preserve the relationship $\varphi^*_{x,\tau} < \varphi^*_{m,\tau}$, and have non-zero exports, for a large enough σ_τ, $f_{m,\tau}$ must increase. This relationship is depicted in Figure 4.8. A downside to this variant is that implausible tax rates are required for Petroleum and Coal Products and Electronic Components and Accessories, as well as large subsidies for other sectors. The reason for this is that with constant markups, the only way to generate high enough differences between FDI sales and exports is by affecting supply side components of prices.

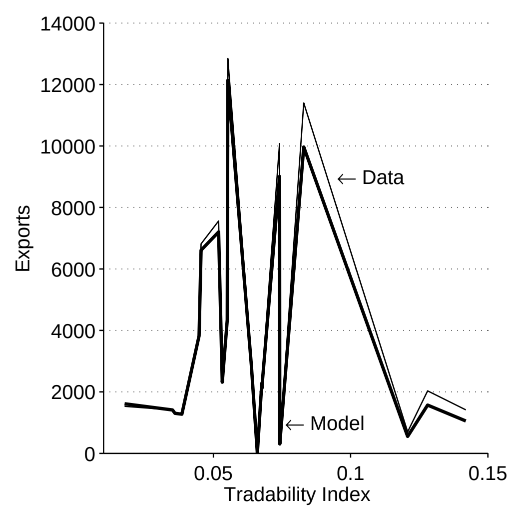
Notice that given our calibration algorithm, the model predicts total sector exports and FDI sales which are very close to the observed values (see Figure 4.9). Additionally, the left panel of Figure 4.10 shows total sector employment arising from the model against observed employment. As in Helpman et al. (2004), we compare non-production workers to fixed FDI costs. This relationship is positive and shown on the right panel of Figure 4.10.

Table 4.3: Industry-specific sales tax

Industry	$\sigma_\tau - 1$
Grain Mill and Bakery Products	-0.234
Other Food and Kindred Products	-0.264
Tobacco Products	-0.207
Textile Products and Apparel	-0.186
Lumber, Wood, Furniture, and Fixtures	-0.043
Paper and Allied Products	-0.110
Chemical Products, nec	0.539
Soap, Cleaners, and Toilet Goods	0.368
Other Chemicals and Allied Products	0.162
Petroleum and Coal Products, nec	14.852
Other Petroleum and Coal Products	7.046
Rubber Products	-0.456
Glass Products	-0.090
Other Stone, Clay, and Other Nonmetallic Mineral Products	0.041
Primary and Fabricated Metals	0.452
Construction, Mining, and Materials Handling Machinery	-0.224
Household Audio and Video, and Communications Equipment	0.735
Electronic Components and Accessories	4.151
Other Electrical Equipment, Appliances, and Components	0.562
Instruments and Related Products	-0.134

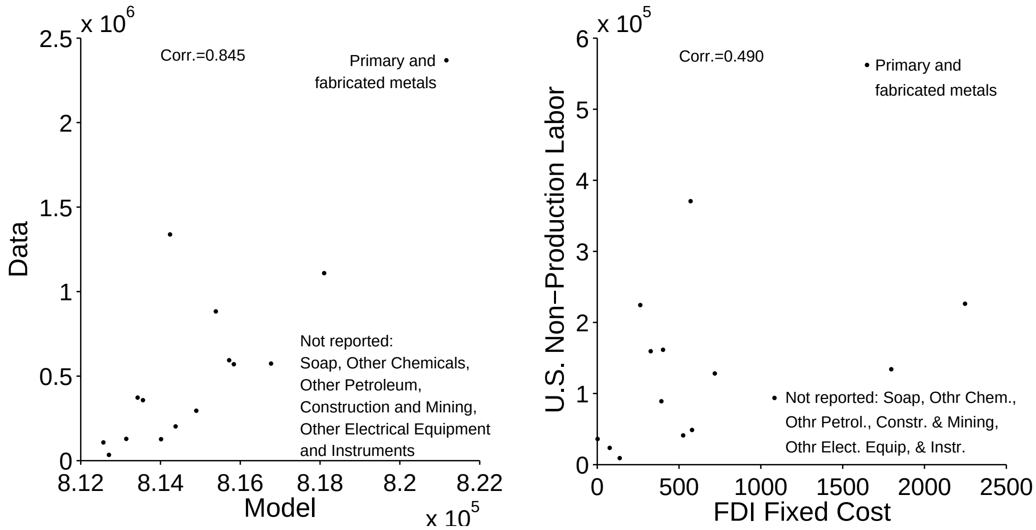


(a) Exports



(b) FDI Sales

Figure 4.9: Sector specific taxes



(a) Employment (b) Fixed cost

Figure 4.10: Sector specific taxes

4.6.5 Sector-specific utility weights (home bias)

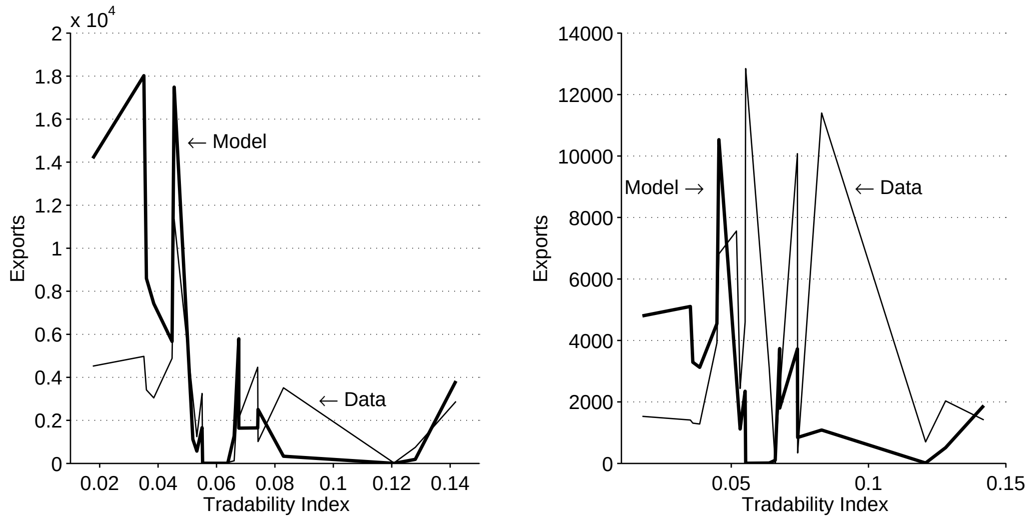
For this specification, we assume that $\alpha_{d,\tau} = \alpha_{m,\tau} = 1, \quad \forall\tau$ and allow for sector-specific $\alpha_{x,\tau}$. We interpret this formulation as consumers having different preferences on locally- versus foreign-produced goods (commonly known as home product bias in the trade literature).

The pricing rules are given by (4.5), the cutoff values by (4.9), and the fixed costs of production must follow:

$$\begin{aligned} f_x &> f_d \left(\frac{\tau}{\alpha_x}\right)^{\frac{\rho}{\rho-1}} && \Leftrightarrow \quad \varphi^*_{d,\tau} < \varphi^*_{x,\tau},\ \forall\tau \\ f_m &> f_x \frac{w^i}{w^j} \left(\frac{w^i}{w^j}\frac{\tau}{\alpha_x}\right)^{\frac{\rho}{1-\rho}} && \Leftrightarrow \quad \varphi^*_{x,\tau} < \varphi^*_{m,\tau},\ \forall\tau \end{aligned}$$

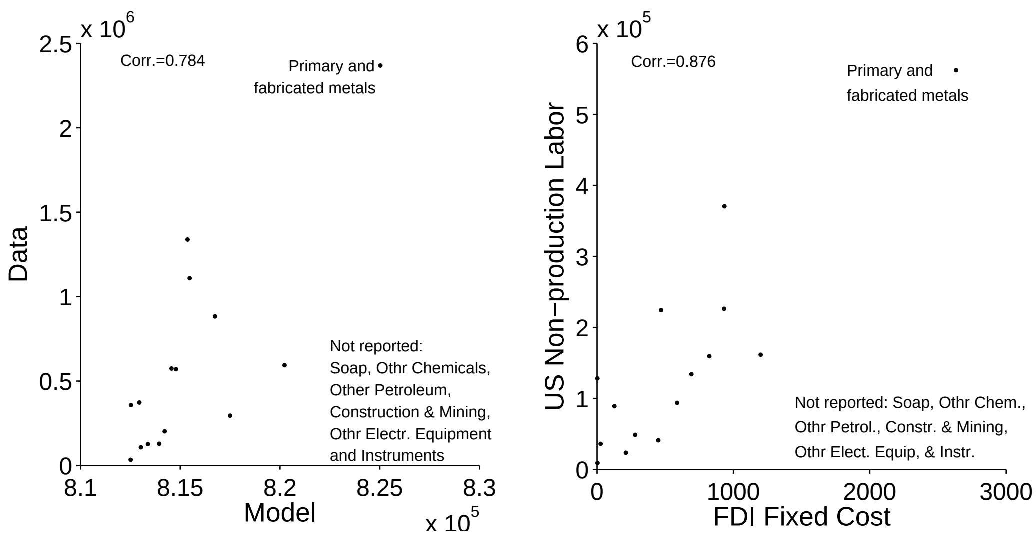
to guarantee consistency with empirical cutoffs. We calculate total sector sales using (4.8) and the corresponding mass of firms. The model can match the ratio of exports to FDI sales, although it fails to match the absolute sectoral sales, as shown in Figure 4.11. This occurs because weights $\alpha_{x,\tau}$ are chosen to match the ratios, directly affecting the cutoff productivities for exporting firms, which did not previously occur.

In spite of this, total sectoral employment in the model is highly correlated with the data (corr.=0.784), which is also the case for non-production workers and fixed FDI costs



(a) Exports (b) FDI sales

Figure 4.11: Sector specific utility weights



(a) Employment (b) Fixed cost

Figure 4.12: Sector specific utility weights

(corr.=0.876, see Figure 4.12). The latter result provided the possibility of calibrating these fixed costs with non-production labor data. Since this data is only available for 15

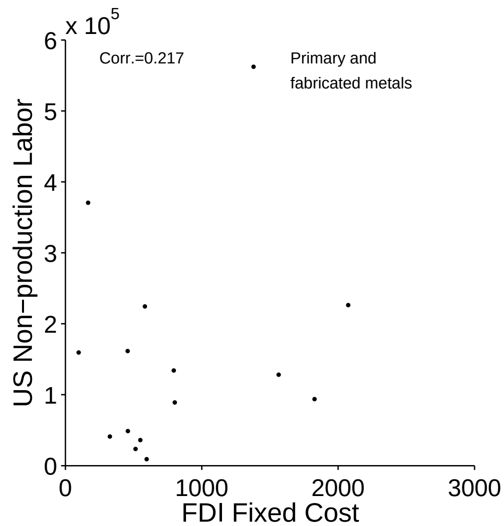


Figure 4.13: Non-production workers vs. fixed FDI Cost (15 sectors)

of the sectors, we recalibrated this version of the model to these 15 sectors. Although we match the ratio of exports to FDI sales, we no longer have a strong relationship between non-production labor and fixed FDI cost (Figure 4.13), hence, we did not pursue this calibration exercise.

4.7 Conclusions

In this paper we determine what is needed to endogenously generate the large variations of exports to FDI sales among sectors. To do so, we build on the Helpman et al. (2004) model of monopolistic competition where firms can choose between the foreign market servicing options of exports and FDI sales. To calibrate this model, we aggregate firms into sectors and we show that tradability and productivity dispersion are not enough to match sectoral data on exports and FDI sales for the U.S. and Canada in 1997.

We offer two alternative variations of our benchmark model that allow us to match these sectoral differences. The first variation is a model with sector-specific taxes on multinational operations and the second one has sectoral home product bias. It is important to note that the required tax rates on multinational firms are in some cases implausible, hence the home product bias model is more appealing.

Future research is required to find less restrictive approaches in sector classification. In particular, our assumption that all the firms in a sector have the same tradability index for their good is inflexible. Additionally, empirical validation of the utility function weights is needed. In spite of the limitations that this class of models present, we believe they have the potential to provide important policy insights regarding foreign market servicing.

Bibliography

Abowd, J. M., J. Haltiwanger, and J. Lane (2004). Integrated Longitudinal Employer-Employee Data for the United States. *American Economic Review 94*(2), 224–229.

Abowd, J. M. and F. Kramarz (1999). The Analysis of Labor Markets Using Matched Employer-Employee Data. In O. C. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics*, Chapter 40, pp. 2629–2710. Elsevier.

Abowd, J. M., F. Kramarz, and D. N. Margolis (1999). High Wage Workers and High Wage Firms. *Econometrica 67*(2), 251–333.

Abowd, J. M., F. Kramarz, and S. Roux (2006). Wages, Mobility and Firm Performance: Advantages and Insights from Using Matched Worker-Firm Data. *The Economic Journal 116*(512), F245–F285.

Abowd, J. M., F. Kramarz, and S. Woodcock (2008). Econometric Analyses of Linked Employer-Employee Data. In L. Mátyás and P. Sevestre (Eds.), *The Econometrics of Panel Data* (Third ed.), Volume 46 of *Advanced Studies in Theoretical and Applied Econometrics*, Chapter 22, pp. 727–760. Springer.

Açikgöz, O. and B. Kaymak (2008). Rising Skill Premium and the Deunionization in the United States. Mimeo, University of Rochester and Université de Montréal.

Acemoglu, D. and V. Guerrieri (2006). Capital Deepening and Non-Balanced Economic Growth. NBER Working Paper 12475, National Bureau of Economic Research.

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek (2004). FDI and Economic Growth: the Role of Local Financial Markets. *Journal of International Economics 64*(1), 89–112.

Alfaro, L., S. Kalemli-Ozcan, and S. Sayek (2009). FDI, Productivity and Financial Development. *The World Economy 32*(1), 111–135.

Alfaro, L. and A. Rodriguez-Clare (2004). Multinationals and Linkages: An Empirical Investigation. 2004 Meeting Papers 145, Society for Economic Dynamics.

Angrist, J. D. and A. B. Krueger (1999). Empirical Strategies in Labor Economics. In O. C. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics*, Volume 3, Chapter 23, pp. 1277–1366. Elsevier.

Arai, M. (2003). Wages, Profits, and Capital Intensity: Evidence from Matched Worker-Firm Data. *Journal of Labor Economics 21*(3), 593–618.

Arkolakis, C. (2008). Market Penetration Costs and the New Consumers Margin in International Trade. Technical report.

Bayoumi, T., D. Laxton, and P. Pesenti (2004). Benefits and Spillovers of Greater Competition in Europe: A Macroeconomic Assesment. Working Paper 10416, National Bureau of Economic Research.

Becker, G. S. (1964). *Human Capital*. New York: Columbia University Press for the National Bureau of Economic Research.

Blanchard, O. and F. Giavazzi (2003). Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets. *The Quarterly Journal of Economics 118*(3), 879–907.

Blanchard, O. J. and N. Kiyotaki (1987). Monopolistic Competition and the Effects of Aggregate Demand. *The American Economic Review 77*(4), 647–666.

Blanchflower, D. G. and A. Bryson (2004). What Effect Do Unions Have on Wages Now and Would Freeman and Medoff Be Surprised? *Journal of Labor Research XXV*(3), 117–128.

Blinder, A. S. (1973). Wage Discrimination: Reduced Form and Structural Estimates. *The Journal of Human Resources 8*(4), 436–455.

Blonigen, B. A. (2001). In Search of Substitution Between Foreign Production and Exports. *Journal of International Economics 53*(1), 81–104.

Brakman, S. and H. Garretsen (2008). *Foreign Direct Investment and the Multinational Enterprise*. MIT Press Books. The MIT Press.

Brown, C. and J. Medoff (2003). Firm Age and Wages. *Journal of Labor Economics 21*(3), 677–697.

Buch, C. M., J. Kleinert, A. Lipponer, and F. Toubal (2005). Determinants and Effects of Foreign Direct Investment: Evidence From German Firm-Level Data. *Economic Policy 20*(41), 52–110.

Buera, F. and J. Koboski (2006). The Rise of the Service Economy. Northwestern University: Mimeo.

Cahuc, P. and A. Zylberberg (2004). *Labor Economics*. Cambridge, Massachusetts: The MIT Press.

Carr, D. L., J. R. Markusen, and K. E. Maskus (2001). Estimating the Knowledge-Capital Model of the Multinational Enterprise. *American Economic Review 91*(3), 693–708.

Chaney, T. (2005). Productivity Overshooting with Heterogeneous Firms. Mimeo, University of Chicago/MIT.

Chaney, T. (2006). Heterogeneous Firms, Market Structure and the Geography of International Trade. Mimeo, University of Chicago/MIT.

Clark, C. (1957). *The Conditions of Economic Progress*. London: MacMillan.

Davies, J. B. and A. F. Shorrocks (2000). The distribution of wealth. In A. Atkinson and F. Bourguignon (Eds.), *Handbook of Income Distribution*, Volume 1 of *Handbook of Income Distribution*, Chapter 11, pp. 605–675. Elsevier.

Dixit, A. K. and J. E. Stiglitz (1977). Monopolistic Competition and Optimum Product Diversity. *American Economic Review 67*(3), 297–308.

Duarte, M. and D. Restuccia (2007). The Role of the Structural Transformation in Aggregate Productivity. Working Paper 300, University of Toronto.

Dunning, J. H. (1973). The Determinants of International Production. *Oxford Economic Papers 25*(3), 289–336.

Echevarria, C. (1997). Changes in Sectoral Composition Associated with Economic Growth. *International Economic Review 38*(2), 431–425.

Echevarria, C. (2000). Non-homothetic Preferences and Growth. *The Journal International Trade & Economic Development 9*(2), 151–171.

Feenstra, R. C., J. Romalis, and P. K. Schott (2002). U.S. Imports, Exports, and Tariff Data, 1989-2001. Technical report.

Gibbons, R. and L. F. Katz (1992). Does Unmeasured Ability Explain Inter-industry Wage Differentials? *Review of Economic Studies 59*(3), 515–35.

Gollin, D., S. Parente, and R. Rogerson (2002). The Role of Agriculture in Development. *The American Economic Review 92*(2), 160–164. Papers and Proceedings of the One Hundred Fourteenth Annual Meeting of the AEA.

Goux, D. and E. Maurin (1999). Persistence of Interindustry Wage Differentials: A Reexamination Using Matched Worker-Firm Panel Data. *Journal of Labor Economics 17*(3), 492–533.

Groningen Growth and Development Centre (2006a). 60-Industry Database, September 2006. Groningen Growth and Development Centre [http://www.ggdc.net/].

Groningen Growth and Development Centre (2006b). Data Sources and Methodology of the 60-Industry Database of the Groningen Growth and Development Centre. Groningen Growth and Development Centre [http://www.ggdc.net/].

Head, K. and J. Ries (2003). Heterogeneity and the FDI versus Export Decision of Japanese Manufacturers. Working Paper 10052, National Bureau of Economic Research.

Heckman, J. J., L. J. Lochner, and P. E. Todd (2003). Fifty Years of Mincer Earnings Regressions. NBER Working Papers 9732, National Bureau of Economic Research.

Helpman, E. (1984). A Simple Theory of International Trade with Multinational Corporations. *Journal of Political Economy 92*(3), 451–471.

Helpman, E., M. J. Melitz, and S. R. Yeaple (2004). Export Versus FDI with Heterogeneous Firms. *American Economic Review 94*(1), 300–316.

Hirsch, B. T. (2008). Sluggish Institutions in a Dynamic World: Can Unions and Industrial Competition Coexist? *Journal of Economic Perspectives 22*(1), 153–176.

Holmlund, B. and J. Zetterberg (1991). Insider Effects in Wage Determination, Evidence from Five Countries. *European Economic Review* (35), 1009–1034.

Jean, S. and G. Nicoletti (2002). Product Market Regulation and Wage Premia in Europe and North America: An Empirical Investigation. OECD Economics Department Working Papers 318, OECD.

Jonsson, M. (2007). The Welfare Cost of Imperfect Competition and Distortionary Taxation. *Review of Economic Dynamics 10*(4), 576–594.

Kahn, L. M. (1998). Collective Bargaining and the Interindustry Wage Structure: International Evidence. *Economica 65*(260), 507–534.

Katz, L. F. and D. H. Autor (1999). Changes in the Wage Structure and Earnings Inequality. In O. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics*, Volume 3, Chapter 26, pp. 1463–1555. Elsevier.

King, M., S. Ruggles, T. Alexander, D. Leicach, and M. Sobek (2008). Integrated Public Use Microdata Series, Current Population Survey: Version 2.0. [Machine-readable database]. Minnesota Population Center [producer and distributor]. [http://cps.ipums.org/cps/index.shtml].

Kongsamut, P., S. Rebelo, and D. Xie (2001). Beyond Balanced Growth. *The Review of Economic Studies 68*(4), 869–882.

Krueger, A. B. and L. H. Summers (1988). Efficiency Wages and the Inter-industry Wage Structure. *Econometrica 56*(2), 259–293.

Kuznets, S. (1957). Quantitative Aspects of Economic Growth of Nations: II. *Economic Development and Cultural Change (Supplement to Vol.) 5*, 3–111.

Kuznets, S. (1966). *Modern Economic Growth.* London: Yale University Press.

Laitner, J. (2000). Structural Change and Economic Growth. *The Review of Economic Studies 67*(3), 454–561.

Layard, R., S. Nickell, and R. Jackman (2005). *Unemployment: Macroeconomic Performance and the Labour Market* (2nd ed.). Oxford University Press.

Lee, D. and K. I. Wolpin (2006). Intersectoral Labor Mobilitity and the Growth of the Service Sector. *Econometrica 74*(1), 1–46.

Markusen, J. R. (2004). *Multinational Firms and the Theory of International Trade.* The MIT Press.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica 71*(6), 1695–1725.

Messina, J. (2006). The Role of Product Market Regulations in the Process of Structural Change. *European Economic Review 50*(7), 1863–1890.

Mincer, J. (1958, August). Investment in Human Capital and Personal Income Distribution. *The Journal of Political Economy 66*(4), 281–302.

Mincer, J. (1974). *Schooling, Experience, and Earnings.* New York: Columbia University Press for the National Bureau of Economic Research.

Mundell, R. A. (1957). International Trade and Factor Mobility. *The American Economic Review 47*(3), 321–335.

Murphy, K. M. and R. H. Topel (1987). Unemployment, Risk, and Earnings: Testing for Equalizing Wage Differences in the Labor Market. In K. Lang and J. S. Leonard (Eds.), *Unemployment and the Structure of Labor Markets*, pp. 103–140. New York and Oxford: Basil Blackwell.

Ngai, R. and C. Pissarides (2007). Structural Change in a Multi-Sector Model of Growth. *The American Economic Review 97*(1), 429–443.

Nocke, V. and S. Yeaple (2007). Cross-border mergers and Acquisitions vs. Greenfield Foreign Direct Investment: The Role of Firm Heterogeneity. *Journal of International Economics 72*(2), 336–365.

Oaxaca, R. (1973). Male-Female Wage Differentials in Urban Labor Markets. *International Economic Review 14*(3).

OECD Statistics Directorate (2007a). Annual National Accounts. Organization of Economic Cooperation and Development [http://puck.sourceoecd.org/].

OECD Statistics Directorate (2007b). Labour Force Statistics. Organization of Economic Cooperation and Development [http://oberon.sourceoecd.org/].

Oi, W. Y. and T. L. Idson (1999). Firm Size and Wages. In O. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics*. Elsevier.

Ricaurte, M. (2008). The Role of Labor Markets in Structural Change. Mimeo, University of Minnesota, Department of Economics.

Rogerson, R. (2008). Structural Transformation and the Deterioration of European Labor Market Outcomes. *Journal of Political Economy 116*(2), 235–259.

Saggi, K. (2002). Trade, Foreign Direct Investment, and International Technology Transfer: A Survey. *World Bank Research Observer 17*(2), 191–235.

Schott, P. (n.d.). Schott's International Economics Resource Page: Trade Data and Concordances. Yale University [http://www.som.yale.edu/faculty/pks4/sub_international.htm].

Slichter, S. H. (1950). Notes on the Structure of Wages. *The Review of Economics and Statistics 32*(1), 80–91.

Stokey, N. (2001). A Quantitative Model of the British Industrial Revolution, 1780-1850. *Carnagie-Rochester Conference Series on Public Policy* (55), 55–109.

U.S. Bureau of Economic Analysis (2006). U.S. Direct Investment Abroad, All Foreign Affiliates, Sales by Industry of Affiliate and Country. U.S. Bureau of Economic Analysis [http://www.bea.gov/bea/di/directinv.htm].

U.S. Bureau of Economic Analysis (2007). Gross-Domestic-Product-by-Industry Accounts, 1947-2007. U.S. Bureau of Economic Analysis [http://www.bea.gov/industry/index.htm].

U.S. Census Bureau (2001). 1997 Economic Census Manfuacturing, General Summary. Technical report.

Wagner, J. (2006). International Firm Activities and Innovation: Evidence from Knowledge Production Functions for German Firms. Technical report.

Weiss, L. W. (1966). Concentration and Labor Earnings. *The American Economic Review 56*(1/2), 96–117.

Woodcock, S. D. (2008). Wage Differentials in the Presence of Unobserved Worker, Firm, and Match Heterogeneity. *Labour Economics 15*(4), 771–793. European Association of Labour Economists 19th annual conference / Firms and Employees.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press.