Market vs. Institutions: The Trade-off Between Unemployment and Wage Inequality Revisited

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Abstract

The trade-off hypothesis suggests that high wage inequality in the US and the UK and high unemployment in countries of continental Europe are the consequence of the same negative change in the demand for the low-skilled under different degree of wage rigidity. However, if labor force participation is not perfectly wage inelastic, then rising wage inequality is likely to be accompanied by an increase in the inactivity rate. An extended version of the trade-off hypothesis is therefore proposed here which states that depending on the institutions that affect wage rigidity, there is a trade-off between unemployment on one hand and wage inequality as well as high inactivity on the other.

This paper uses a labor supply and labor demand model with heterogenous types of labor in order to test the trade-off hypothesis and to analyze the effect of market forces and wage rigidity on changes in the between-group variation in earnings, employment, unemployment, and inactivity in France, the UK, and the US between 1990 and 2002. The results provide partial evidence in favor of the trade-off hypothesis, as well as its extended version. In addition, the counterfactual simulations based on the estimated model reveal that exogenous changes in the relative demand for skills dominated in France, while supply shifts had more impact in the US over the studied period. In the UK, the opposite effects of the supply and the demand shifts were of similar magnitude, but the supply effects dominated for the least and the most educated.

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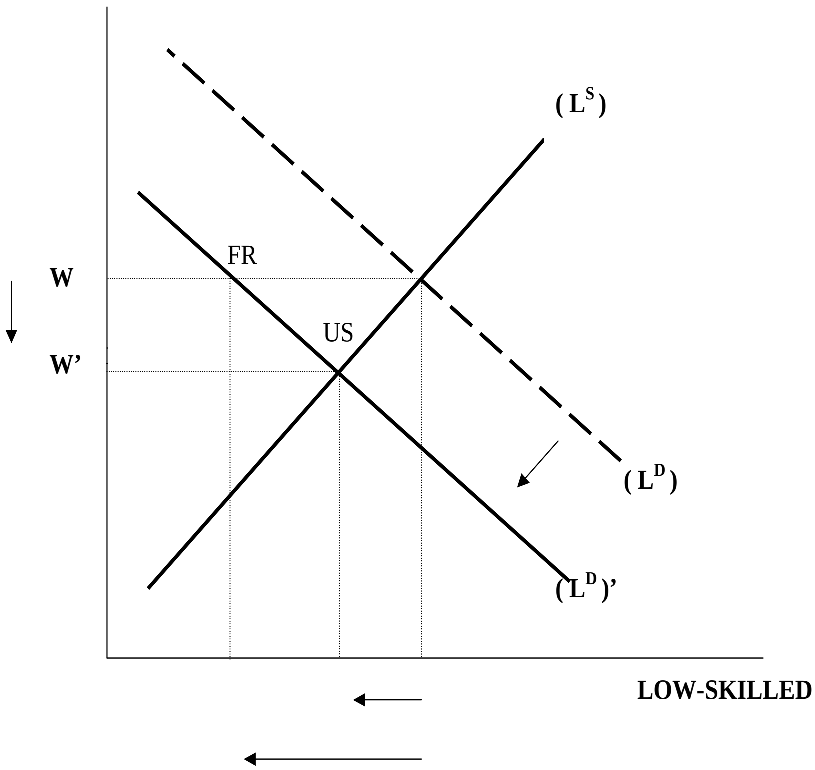
1 Introduction

Over the last three decades, labor markets in the US and in countries of continental Europe have suffered from two contrasting phenomena: while wage inequality has increased in the US and the UK, unemployment has been steadily rising in France and other countries of continental Europe. It has been proposed[2] that the two phenomena have the same cause, namely the decline in the demand for the low-skilled, primarily as a result of skill-biased technological progress. The reason why the negative shift in the demand for the low-skilled has had different consequences in the various countries was suggested to be the differences in their labor market institutions that affect the flexibility of wages. This idea, which has become known in the literature as the trade-off hypothesis, is based on a simple static model of labor supply and labor demand, as given in Figure 1.[3]

Figure 1: The Trade-off Hypothesis



The figure shows the effect of the adverse demand shift on the *relative* earnings and employment of the low-skilled (relative to the high-skilled) in a country where wages are

[2] See e.g. Krugman (1994) or Blank (1997).
[3] Alternatively, it is referred to as Krugman hypothesis.

rigid, such as France, and in a country where wages are flexible, such as the US. In other words, when wages are flexible, negative change in the demand for the low-skilled is likely to affect their wages rather (or more) than their employment, whereas in an economy where wages are rigid the adverse demand effect will be entirely pronounced in the rise of the unemployment of the low-skilled.

In the extreme case, when labor supply is wage inelastic, the adverse demand shift in flexible labor market affects only wages while employment remains at its initial level.[4] However, when labor supply in countries with high wage flexibility is not perfectly inelastic, the deterioration of relative wages of the low-skilled may reduce their incentives to work. As shown in Figure 1, although the resulting unemployment caused by the adverse demand shift is lower (or even zero, as in this case) in countries where wages fully adjust, inactivity among the low-skilled rises in response to the decline in the relative wage, leaving the gap between the employment rate in the countries with rigid and flexible wages, such as France versus the US, smaller than the original trade-off hypothesis would suggest.[5] The first point this paper would like to make is that *if labor supply*, defined as labor force participation, *is not perfectly wage inelastic, then the standard trade-off hypothesis is incomplete.* In what follows an extended trade-off hypothesis is proposed that does take into account the effect of wages on inactivity. In addition to what the standard trade-off hypothesis suggests, the extended version states that if labor supply is sensitive to wages then the increase in wage inequality and the deterioration of absolute or relative wages of the low-skilled in countries where wages are flexible are likely to be accompanied by an increase in inactivity. In this sense, depending on the labor market institutions, the trade-off that the policy-makers may face is the choice between rising wage inequality as well as inactivity rates on one hand and rising unemployment on the other.

The present analysis focuses on the cases of France, the UK and the US during the last decade of the 20th century. France, the UK and the US represent economies with different degrees of labor market regulations and wage flexibility, with the US as the most flexible and France as the least. These two cases also seem to fit into the argument of the trade-off hypothesis, as the US has experienced high and rising wage inequality and low and declining unemployment, while the opposite has been true for France. The 90th to 10th percentile of the wage distribution of men increased from 4.4 to 4.8 and that of women increased from 3.7 to 4.1 in the US between 1990 and 2000, according to the OECD statistics. In France, wage inequality actually declined from 3.5 to 3.3 for men and from 2.9 to 2.7 for women, using the same measure. The average overall unemployment rate during the same period was 10.8 percent in France, but only 5.5 percent in the US. The UK seems to be somewhere in between, as its rising wage inequality was also complemented by a relatively high unemployment until the mid-1990s. The rise in wage dispersion in the UK was somewhat slower than in the US – from 3.3 to 3.4 for men and from 2.9 to 3.1 for women – whereas the average unemployment rate there was 7.8

[4] Labor supply in Figure 1 and in the context of this paper corresponds to labor force participation, and in what follows the two terms will be used interchangeably.

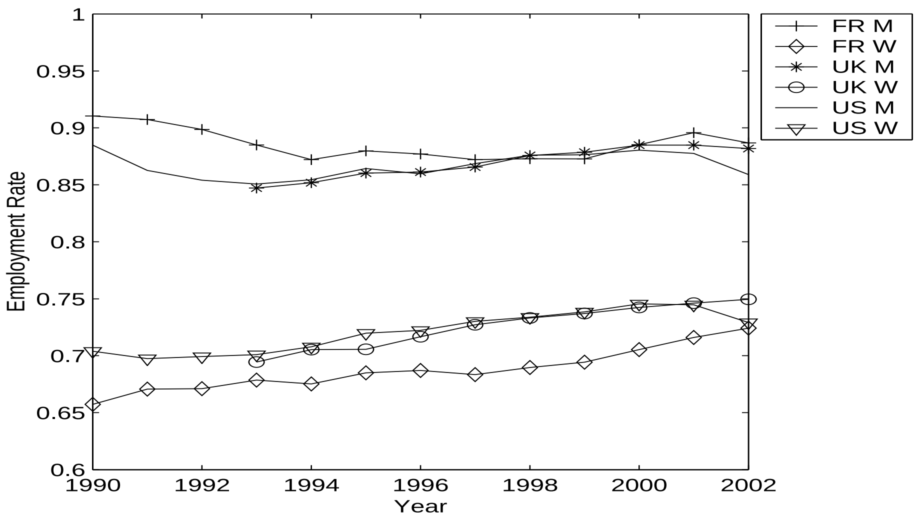
[5] In this context, inactivity is the state of voluntary non-employment, i.e. when a non-working individual declines to seek employment. This state is also often called labor force non-participation. These two terms will be used interchangeably in this paper.

percent. Using the aggregate figures by gender, the observed cross-country differences in the levels of unemployment and wage dispersion seem therefore consistent with the standard trade-off hypothesis.

The labor force participation and inactivity of women traditionally reflects social and cultural values, as well as economic factors. The average inactivity rate of prime age women in the three countries were 23.5 percent in France, 25.6 percent in the UK and 24.5 percent in the US.

The average inactivity rate among prime age men between 1990 and 2000 was only 5.1 percent in France, while it was 7.2 percent in the UK and 7.8 percent in the US. Although it had an upward trend in all three countries, it increased the least in France and the most in the US. If we add up the unemployed and the inactive, the total non-employment rate among prime age men – and this deserves to be emphasized – was similar across the three countries in the period under analysis. Thus, the average employment rate (one minus the non-employment rate) among prime age men during the 1990s was thus also similar in the three countries: 87.1 percent in France, 85.9 percent in the UK and 88 percent in the US.

Figure 2: Employment Rate



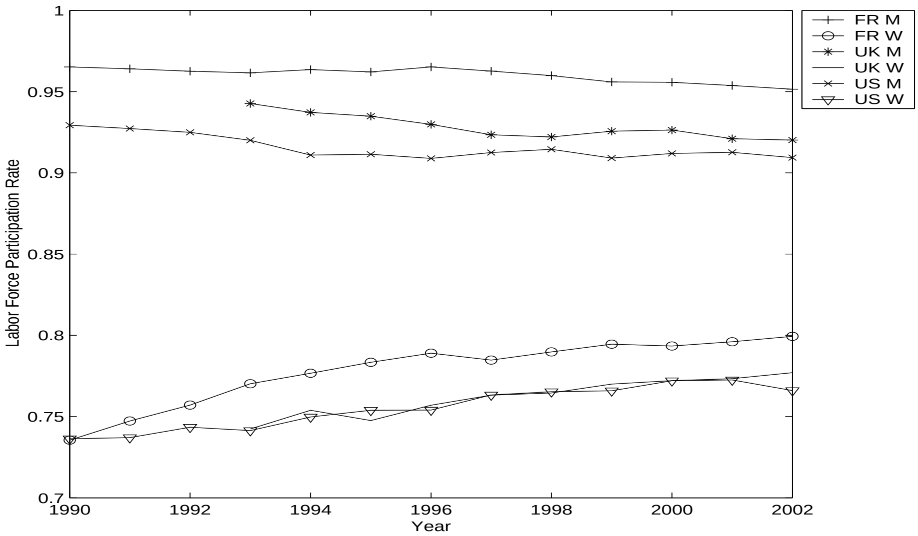
Out-of-school civilian prime age (24-54) population: men (M) and women (W) in France, the UK and the US.

Employment rates for both men and women for the three countries in the studied period are shown in Figure 2.

The data on prime age men in France, the UK and the US seem to suggest that there is a trade-off between high unemployment and high inactivity.

Figure 3 shows how the cross-country differences in inactivity versus unemployment are reflected in the three countries' labor force participation rates: we can see that labor force participation of French men and women is higher by several percentage points than

Figure 3: Labor Force Participation Rate



Out-of-school civilian prime age (24-54) population: men (M) and women (W) in France, the UK and the US.

the corresponding rates of men and women in the two other countries. However, the higher inactivity rates in the US and the UK "make up" for the greater proportion of unemployed in France, leaving the employment rates (in particular among men) similar, as was indicated in Figure 2. The relatively high inactivity rates among prime age men in the US and the UK (i.e. countries with high wage flexibility) when compared to France, are consistent with the extended version of the trade-off hypothesis.

Although the trade-off hypothesis and its extended form seem to have some empirical relevance when looking at the aggregate data for the three countries during the studied period, in order to test the validity of these theories, it is necessary to have the labor force status data disaggregated for different earning levels.

There are only very few papers that directly test the trade-off hypothesis. Nickell and Bell (1995, 1996), Krueger and Pischke (1997), Gottschalk and Joyce (1998), Card, Kramarz and Lemieux (1999), Puhani (2005) are the only available analyses here. The evidence is mixed: while Card, Kramarz and Lemieux (1999) reject the hypothesis for France, Canada and the US during the 1980s, Puhani (2005), focusing on the UK, the US and Germany, finds evidence in favor of the hypothesis for the 1980s and 1990s when comparing the last two of the countries.

This paper uses a labor supply and labor demand model with heterogenous types of labor in order to test the trade-off hypothesis and to analyze the effect of market forces and wage rigidity on changes in the between-group variation in earnings, employment, unemployment, and inactivity in France, the UK, and the US over time between 1990 and 2002. The theoretical framework of this analysis builds on the work from Card, Kramarz and Lemieux (1999). However, the full structure of their model is utilized here, so as to describe not only employment but all three labor force states (employment, unemployment, inactivity), as well as earnings. The methodological differences between this paper and that of Card et al.(1999) are discussed wherever relevant.

Following Card et al.(1999), labor market is described by a structural model of labor supply and labor demand that allows for wage rigidity, and consequently regards unemployment as a disequilibrium phenomenon. The demand for different types of labor is derived from a CES production function, and the labor supply is also allowed to vary across labor types. Exogenous supply and demand shifters are included in the model in order to help identify the source of the observed changes in earnings and labor force status. The supply shifters are: the skill-group's share within the population; the proportion of individuals who are married; and the proportion of individuals whose households include pre-school children. The latter two factors are allowed to affect male and female skill-groups in a different way. The demand shifter is the share of the skill-group in the total value added produced in the economy in the current year. The exogenous changes in the demand for different types of labor are therefore linked to the changes in the demand in different industries, rather than to a particular source of these changes, as is typically done in the literature. This specification allows the shocks to the relative demand for skills to be caused by any of the often mentioned factors, such as skill-biased technological progress or an increase in international trade, without making any assumptions about which one of them dominated.

A reduced form system of three equations for wage, employment, and labor force participation implied by the structural model is estimated on group-level panel data for the 1990-2002 period constructed from the following labor force surveys: *Enquête Emploi* for France, *Labor Force Survey* for the UK, and the *March CPS* for the US. The skill-groups (labor types) classification is based on gender, age, and education. The structural parameters of the model are recovered from the reduced form estimates, using minimum distance methods with equally and optimally weighted moments.

The trade-off hypothesis is tested using both the reduced form and the structural parameter estimates. The hypothesis implies that wages should be more sensitive to the exogenous changes in the demand and supply in the US and the UK, countries where wages are flexible, than in France. The opposite should hold for the employment rate. The reduced form coefficients from the wage and the employment equations are explored in order to assess the validity of this prediction. The degree of wage flexibility is estimated as a structural parameter of the model, and its value implies to what extent labor market institutions made wages rigid as well as whether this rigidity affected the evolution of wages and labor force status proportions in the three countries during the analyzed period.

The estimation results are further used to construct counterfactual series that hold the supply or the demand shifters constant at their initial levels. These simulations show what would have happened had there been no exogenous changes in the demand or supply respectively. A comparison of the actual and the simulated series reveals what factors stood behind the development in earnings and labor force status in different skill-groups in the three countries, and which of one these factors dominated.

The findings do provide partial evidence in favor of the standard trade-off hypothesis as well as its extended version. The reduced form estimates indicate that while wage responsiveness to the demand shifters does not vary across the three countries, employment is, in accordance with the trade-off hypothesis, more sensitive to the exogenous changes in the demand in France than in the other two countries. The estimate of the wage flexibility parameter is lower in France than in the other two countries. This result suggests that institutions that enhance wage rigidity played an important role in the earnings and labor force status developments in France during the period under analysis.

The positive and significant values of the wage elasticity of labor force participation for all three countries suggest that the high inactivity rates in the US and the UK, in particular among low-skilled men, could be a consequence of the continuing deterioration of the relative wages of the low-skilled, in accord with the proposed extended version of the trade-off hypothesis.

Simulations based on the estimated model show that exogenous changes in the demand dominated the employment rates across the education groups in France, while supply shifts had more impact in the US. In the UK, the opposite effects of the supply and the demand shifts were of similar magnitude, with the supply effects dominating for the least and the most educated.

This paper has the following structure: The introduction is followed by two sections that present the structural model and the estimation strategy respectively. The Empirical Facts section then describes the data and surveys the main trends in the between-group variation in earnings and labor force status in the three countries over the analyzed period. Estimation Results section, which comes next, presents and discusses the main findings. It is followed by the Conclusion. The Appendix consists of five parts: Data Description and Sources; Figures; Other Results; Model Details; and Estimation Details.

2 Theoretical Model

The theoretical framework of the present analysis is based on a static model of labor supply and labor demand with heterogenous labor. The model treats unemployment as a disequilibrium phenomenon caused by labor market institutions which prevent wages from being equal to their market clearing values. As mentioned above, the theoretical model is based on that in Card, Kramarz, and Lemieux (1999), with some extensions that I discuss at the end of this section.

In this model, population is composed of J labor types[6] that differ both in skills and reservation wages. A single homogenous product Y is produced from J labor inputs in the economy according to a constant returns CES production function, as follows:

$$Y = f(L_1, L_2, ..L_J) = \Big(\sum_j (c_j \; L_j)^{\frac{\sigma-1}{\sigma}} \Big)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where σ is the elasticity of substitution between any two inputs, and c_j is the relative efficiency parameter for skill group j.

[6] In what follows, I will refer to the groups of the different labor types as "skill groups". The empirical analysis defines a skill group on the basis of gender, age and education.

The labor demand for input j, implied[7] by this production function, is:

$$\ln(L_j^d) = \ln(Y) - \sigma \ \ln(w_j) + (\sigma - 1) \ \ln(c_j) \tag{2}$$

where w_j is the average wage[8] received by the labor type j.

Divided by the total number of individuals in the group, the labor demand for skill group j, expressed in proportions, and including the error term, becomes:

$$\ln(l_j^d) = \ln(y) - \sigma \ \ln(w_j) + (\sigma - 1) \ \ln(c_j) - \ln(p_j) + \nu_j^d \tag{3}$$

where $l_j^d = \frac{L_j^d}{P_j}$ is the proportion of individuals in group j who are employed, $p_j = \frac{P_j}{P}$ is the proportion of labor type j in population, $y = \frac{Y}{P}$ is the per capita output, and ν_j^d is the error term in the labor demand equation.
The labor supply of the skill group j depends on the average wage offer[9] w_j for the labor type j, and two exogenous factors that affect the incentives to work (the reservation wage) of the individuals in the skill group j: marital status and presence of children. The two exogenous factors are expressed in proportions and reflect the typical characteristics of the individuals of the particular labor type.[10] The labor supply is described by the participation rate l_j^S, i.e. proportion of individuals in group j that are in the labor force, and has the following functional form:[11]

$$l_j^s = \frac{L_j^s}{P_j} = w_j^{\varepsilon} \ \exp(\alpha_j + \beta^g \ m_j + \gamma^g \ k_j) \tag{4}$$

where ε is the wage elasticity common to all groups, α_j is the time-invariant group-specific heterogeneity in preferences, m_j is the proportion of individuals who are married, and k_j is the proportion of individuals living in households that include pre-school children. As common knowledge and previous empirical findings suggest, marital status and the presence of pre-school children typically affect women and men in a different, and often quite opposite, ways. The coefficients of these two factors are therefore assumed to differ by gender, where $g = f$ for the skill groups of women, and $g = m$ for the skill groups of men.

Expressed in logarithms, and including the error term ν_j^s, the labor supply is given by

$$\ln(l_j^s) = \alpha_j + \varepsilon \ \ln(w_j) + \beta^g \ m_j + \gamma^g \ k_j + \nu_j^s \tag{5}$$

The market clearing wage w_j^* for group j is given by

$$l_j^s(w_j^*) \equiv l_j^d(w_j^*) \tag{6}$$

[7] See Section D of the Appendix for the derivation.

[8] w_j is the wage that the economy pays on average to labor type j.

[9] The average wage offer w_j can be thought of as the unconditional expected wage for an individual of the labor type j.

[10] For example, the proportion of individuals whose households include pre-school children will be higher among younger skill groups.

[11] As the labor supply in this model is defined as the proportion of individuals in the labor force, in what follows I use the terms labor supply and labor force participation interchangeably.

and equals

$$\ln(w_j^*) = \frac{1}{\varepsilon + \sigma} \left[ln(y) - \alpha_j - \beta^g \; m_j - \gamma^g \; k_j + (\sigma - 1) \; \ln(c_j) - \ln(p_j) + \nu_j^d - \nu_j^s \right] \quad (7)$$

In the presence of labor market institutions that limit wage flexibility, such as minimum wage, collective bargaining or high unemployment benefits, the actual wage may differ from its market clearing value. Similar to Card, Kramarz, and Lemieux (1999), I assume the following relationship between the actual and the market clearing wage for group j:

$$\ln(w_j) = \eta + \omega_j + \rho \; \ln(w_j^*) + \nu_j^w \quad (8)$$

where $\rho \in \langle 0, 1 \rangle$ is a coefficient of wage flexibility,[12] whereas ω_j and η represent the time-invariant group-specific and the time-variant overall institutional effects, respectively.[13]

Equation 8 is rather restrictive and captures the three major simplifications of the model. First, there are no equilibrating tendencies in this disequilibrium model. The actual wage is a function of the current market-clearing wage, but it does not depend in any way on the past gaps between the actual and the market-clearing wage. This is due to the fact that this is a static model that cannot capture any gradual adjustment towards the equilibrium. Incorporating the dynamic features would substantially change the entire set-up of the model and make its estimation much more complex; this would lead to a different paper.

Second, the coefficient ρ that describes the sensitivity of the actual wage to the market-clearing wage, is restricted to be the same for all the skill-groups. This assumption is required for the model to be estimable in the present form. It suggests that all the skill groups experience a similar degree of wage rigidity. This would be violated for example if wages of the least skilled were affected by the labor market institutions to a greater extent than the wages of the high skilled. This is likely to be the case for example in case of the effect of high minimum wage. On the other hand, imposing ρ to be the same across groups is consistent with the fact that in some countries, wages *at all levels* are determined by negotiations of the relevant parties (employers, unions or other employees' interest groups, and the governments) rather than by the market.[14] Industry-wide collective bargaining in France is an example of such centralized wage determination process. The responsiveness of the actual wages to the market forces (as captured by the market-clearing wage) may then be similar across different skill-groups.

This assumption can in principle be relaxed by allowing ρ to differ for certain groups, in a similar manner as the marital status and the presence of children coefficients in the

[12] Note that expressed in changes over time and assuming that $\Delta\eta = 0$ (no institutional change) and $\Delta\nu_j^w = 0$, $\Delta \ln(w_j) = \rho \, \Delta \ln(w_j^*)$. ρ also represents the proportion of the actual wage that corresponds to the market clearing wage.

[13] As many policy changes affect only some of the skill groups, there should ideally be time-varying group-specific institutional effects as part of the resulting actual wage. Unfortunately, the present model specification and the estimation strategy does not allow the group-specific effects to vary over time. See the discussion in the text that follows.

[14] There are different degrees of centralization of this process in different countries, as the negotiations take place at the nation, industry or firm levels

labor supply equation are allowed to vary by gender. However, the choice of the variation[15] would be arbitrary, and the extension involves adding even more coefficients to the model which (with the group and year effects) is already rather over-parameterized.

Third, although the gap between the actual and the market-clearing wage can change over time in aggregate (through ν_t), the skill-group variation in this gap (captured by ω_j) stays constant. Again, this assumption is likely to be violated due to the different effect of the labor market institutions across skill-groups. The main interpretation here is again the centralized wage negotiations that would maintain the cross-group differences the same.[16]

A possible way of relaxing the last assumption is to include in equation 8 all the other time-varying exogenous factors that are in the model, without imposing any structural restrictions on their coefficients.[17] This would make the relationship of the actual and the market-clearing wage more flexible. To some extent, the presence of the other time-varying exogenous factors could also capture the adjustment process towards equilibrium and therefore relax (but only in the estimation, not structurally) the absence of the equilibrating forces discussed above. The last two extensions are part of the author's future research agenda.

As already suggested, unemployment u_j,[18] given by

$$u_j \equiv l_j^s - l_j^d \tag{9}$$

is a disequilibrium phenomenon in this model.[19] Within this theoretical framework, the empirical fact that at any point in time there is some unemployment observed in each skill group, suggests that the actual wage is always above the market clearing wage, $\ln(w_j) > \ln(w_j^*)$. This implies that the employment in group j is determined by the demand

$$e_j \equiv l_{jt}^d \tag{10}$$

It also implies that wages are rigid downwards but not upwards.

If we define the proportion of inactive in group j as n_j, we can write down an identity relationship that asserts that the proportions in the three labor force states in group j (by definition) add to one.

$$e_j + u_j + n_j \equiv 1 \tag{11}$$

Equations 3, 5, 6, 8, 9, 10, and D.2 form a system of structural equations that describe the model. The above-described model can be expressed in a reduced form as a system of equations of the four endogenously determined variables (wage w_j, the proportions

[15] The estimation strategy does not allow group-specific ρ, so it is necessary to choose the set of the skill-groups for which it will be the same.

[16] This is again violated by the specific effect of the minimum wage on the low skilled. However, the indexation of the minimum wage to the average manufacturing wage in France supports the plausibility of the constant gaps at least for certain groups at the lower half of the distribution.

[17] They already enter the equation structurally through the market clearing wage w_j^*.

[18] Unemployment u_j is here defined as the proportion of unemployed in (the population of) group j, rather than in the labor force, as in the traditional definition of the unemployment rate.

[19] In terms of macroeconomic terminology, there is no frictional unemployment in this model. This is conceptually consistent with the static nature of the model.

of employed e_j, unemployed u_j, and inactive n_j in group j), stated as functions of the exogenous factors. As the three equations for the labor force status proportions add to one, one of them is redundant. If I add the time subscripts, express the endogenous factors in logarithmic form, and use, as a left-hand-side variable, the logarithm of labor supply $\ln(l_j^s)$, that equals $\ln(e_j + u_j)$, rather than unemployment or inactivity, it leads to the following linear system of three equations:

$$\begin{aligned}
\ln(w_{jt}) &= \pi_{0t}^w + \pi_{1j}^w + \pi_p^w \ln(p_{jt}) + \pi_c^w \ln(c_{jt}) + \pi_m^{g\,w} m_{jt} + \pi_k^{g\,w} k_{jt} + \xi_{jt}^w && (12)\\
\ln(e_{jt}) &= \pi_{0t}^e + \pi_{1j}^e + \pi_p^e \ln(p_{jt}) + \pi_c^e \ln(c_{jt}) + \pi_m^{g\,e} m_{jt} + \pi_k^{g\,e} k_{jt} + \xi_{jt}^e && (13)\\
\ln(l_{jt}^s) &= \pi_{0t}^s + \pi_{sj}^s + \pi_p^s \ln(p_{jt}) + \pi_c^s \ln(c_{jt}) + \pi_m^{g\,s} m_{jt} + \pi_k^{g\,s} k_{jt} + \xi_{jt}^s && (14)
\end{aligned}$$

where the π-s represent the reduced form parameters that are functions of the structural parameters: σ, ε, ρ, β^f, β^m, γ^f, γ^m, α_j, ω_j, $\ln(y_t)$, and η_t. Note that, again, coefficients $\pi_m^{g\,i}$ and $\pi_k^{g\,i}$ (where $i \in w, e, s$) differ by gender ($g = f, m$). The ξ-s represent the reduced form error terms that are functions of some of the structural parameters and the error terms ν_j^d, ν_j^s, and ν_j^w. See Section D of the Appendix for the mapping between the structural and the reduced form parameters, and the structural and the reduced form error terms. All key structural parameters can be identified from the reduced form estimates. Identification of the model is shown in Section D.2 in the Appendix.
Similar to Card, Kramarz, and Lemieux (1999),[20] I substitute the relative efficiency parameters c_{jt}, which are not observed, with an instrument $\tilde{c}_{jt}$, assuming that the instrument determines the unobserved variable in the following way.

$$\ln(c_{jt}) = \lambda_{0\,t} + \lambda_1\ \ln(\tilde{c}_{jt}) + \nu_{jt}^c \qquad (15)$$

where $\lambda_{0\,t}$ and λ_1 are parameters describing the relationship between the unobserved c_{jt} and its instrument, and ν_{jt}^c is the error term. Thus, the actual reduced form coefficients of the exogenous demand shifters that are estimated, are $\pi_{\tilde{c}}^i = \lambda_1\ \pi_c^i$ and $\tilde{\pi}_{0t}^i = \pi_{0t}^i + \pi_c^i\ \lambda_{0\,t}$, and the reduced form error terms $\tilde{\xi}_{jt}^i = \xi_{jt}^i + \pi_c^i\ \nu_{jt}^c$ where $i \in w, e, s$.I describe the demand shifter used to determine c_{jt} the next section (Section 3).

There are two key differences between this model and the one in Card, Kramarz, and Lemieux (1999). The first difference is the presence of the third equation. Card et al. (1999) write down only the wage and labor supply equations, however, they use employment rate for the estimation of the latter.[21] If we use their theoretical framework fully, it leads to a third equation, similar to the one presented in this section. Although this is not required for the identification of the parameters, as the model is already over-identified even if using only two equations, it can improve the precision with which the structural coefficients are estimated (see Section D.2 in the Appendix for the identification results). In addition, the estimation of the labor supply equation provides information about labor force participation and inactivity, which is of key interest for

[20] Card at al. (1999) write down the following relationship between the relative efficiency term and their instrument: $(\sigma - 1)\Delta \ln(c_{jt}) = \alpha + \beta\, D_j + u_j$ where D_j is either the initial wage level or the proportion of individuals using computer at work at the end of the period.

[21] In this respect, the estimated coefficients are also given an incorrect structural interpretation.

this work. The second difference between the model of Card et al. (1999) and mine is the presence of the true exogenous supply shifters, i.e. marital status and the presence of pre-school children. Card et al. (1999) use the population share as the only proxy for the "exogenous changes" in the labor supply. However, this term enters in the model as an "accounting" result, when the labor demand equation is transformed from levels to proportions (equations 2 and 3). The author believes that using the true supply shifters as well as demand shifters improves the identification of the model.

As in Card et al. (1999), the present model makes several "seriously oversimplifying" assumptions[22] that should be kept in mind when interpreting the results. In addition to the restrictions imposed by equation 8 as discussed above, these are, in particular, the same elasticity of substitution between any two of the skill groups, the common wage elasticity of the labor force participation for all the skill groups, and the production of one homogenous product.

3 Estimation Strategy

The theoretical model presented in the previous section and described in the reduced form by the system of the three equations 12, 13 and 14 is estimated on the group-level data, as constructed from the individual-level data from the series of national labor force surveys conducted in the three countries over the 1990s. The skill groups are based on gender, age and education.[23]

To take into account the group specific heterogeneity in preferences, and in the group-specific institutional component affecting the actual wage, the model is estimated with the group fixed effects present in each of the three equations. Year fixed effects are also included in all equations, so as to capture the aggregate development of the economy over time (changes in y_t) and the changes in institutions that affect all the skill-groups in the same way (changes in η_t). With the group and the year fixed effects, the present analysis focuses on the *changes* in the between-group variation in earnings and labor force status, rather than on the differences in their *levels*.[24]

The system of equations 12 to 14 is estimated jointly, allowing for the error terms to be correlated across the three equations. The three equations form a seemingly unrelated regression equations (SURE) system with the same right-hand-side variables, so that the joint and equation-by-equation estimations give identical results. However, joint estimation is necessary for obtaining the cross-equation covariances of the reduced form parameter estimates from different equations. The overall covariance matrix of all the reduced form parameter estimates is required for the minimum distance method with optimal weighting which is used to compute the structural parameters, as discussed later in this section.

[22] These are the necessary assumptions that keep the theoretical model manageable and enable us to estimate it with the available data.

[23] See Section A in the Appendix for details. The group-level data were constructed as group-specific means or proportions. The only exceptions are the demand shifter and the group-specific wage, both described later in this section.

[24] As it is based solely on group-level data, the present analysis completely ignores any within-group variation.

The fact that the group-level variables are constructed as means or proportions from the individual level data builds into the model group-wise heteroskedasticity, as the variance of the within group averaged individual error term varies with the sample size. In addition, the binary nature of the employment and labor force participation indicators further implies a specific form of the heteroskedasticity present in the log-linear models of the proportion data. Variables in the three equations are therefore transformed with appropriate weights to eliminate these forms of heteroskedasticity. See Section E.1 in the Appendix for the detailed discussion and derivation of weights used for different estimation specifications.

The present analysis estimates the three equations jointly, both using the "plain" group-level variables (neglecting group-wise heteroskedasticity) and using the variables transformed by the weights.[25] As the estimation involves not only the group means and proportions but also generated regressors (the constructed demand shifters and, in several specifications, the mean or medians of predicted wages), bootstrapped standard errors would probably be the most appropriate in this set-up. However, the method would require us to bootstrap from the original individual datasets by year, and collapse and merge the data and estimate the joint system at every replication which is a rather computationally-intensive exercise and for the present remains beyond the scope of the paper.

There are two main differences between the estimation methodology in this work and the one employed in Card et al. (1999). First, whereas in Card et al. (1999) the model is estimated using a cross-section of the first differences (over the 1980s), here it is estimated with year fixed effects on an annual panel of the skill groups of 10 to 13 years. In some sense, the present analysis captures the short-term changes, too, whereas Card et al. (1999) focus primarily at the long-term developments. Second, it seems that Card et al. (1999) estimate the two equations of their model separately by weighted least squares using the fraction of the skill group in population (therefore neglecting the proportion nature of the employment data).[26]

Minimum distance method with equal and optimal weighting[27] (i.e. the method of moments and the generalized method of moments) are used to recover the structural parameters from the estimated reduced form coefficients. Section E.3 in the Appendix describes the two methods. The moments are defined by the correspondences between the structural and the reduced form parameters, as described in Table D.1 in Section D of the Appendix. The moments in GMM are weighted by the inverse of the covariance matrix of the coefficients from the joint estimation of the three equations.

There are two approaches employed in constructing the group-specific wage. First, I use the median of the logarithm of the real hourly wages observed in each group. Second, I use the median of the logarithm of the real hourly wages predicted to everybody in a

[25] Note that in this case the transformed RHS variables are no longer identical (as the weights differ equation by equation), so the joint and the separate estimations do not produce computationally identical estimates any more.

[26] However, they do state that their results are similar whether weighted or not, and suggest that other kinds of weights (not specified) were also used for the sensitivity analysis.

[27] See for example Greene (2002, pp.536-538) or Wooldridge(2002, pp.442-445) for the textbook exposition.

group by the usual two-equation model of Heckman. The details of the specification of the selection and the wage equations in the Heckman model are given in Section E.2 in the Appendix. The second procedure is preferred, as it corrects the potential selection bias present in the previously mentioned group-specific wage estimates. I also alternate medians with means, and use weekly, monthly or annual wages[28] (when the information is available in the data) to check the sensitivity of the results. Part of the output of the sensitivity analysis is included in Section C of the Appendix.[29]

The demand shifter that serves as an instrument for the relative efficiency parameters is the skill-group share in the total value added produced in the current year in the whole economy of the given country (*lnva*). The information about each individual's industry is employed to map the industry specific information to the skill-group data. The demand shifter is constructed in the following way:

$$lnva_{jt} = \ln\left(\sum_i p_{ijt}\, S_{it}^{va}\right)$$

where i is the industry identifier, $p_{ij} = \frac{N_{ijt}}{N_{it}}$ is the proportion of individuals from group j among the total number of individuals in industry i in year t, and S_{it}^{va} is the percentage share of industry i in the total value added in the economy in year t. The information about the value added shares of industries come from the OECD STAN database. There are 23 to 25 industry groups per country.[30] The change in the share of the total value added is likely to be correlated with the change in the relative efficiency of the skill-group, and in general with the labor demand for the individuals from that group. At the same time, the timing of the labor force survey should rule out potential endogeneity of this demand shifter, as the surveys take place early in the year (in March),[31] while the share is calculated from the total value added over the entire year. And to repeat, it is the year-to-year change in this share in the value added that is used to explain the change in the March wages and the labor force proportions between the two years.[32]

[28] I use the wage information of the full-time workers only when using other measures than the hourly wage.

[29] I cannot use the method of imputing the missing wages with the minimum wage or assuming that they are below the overall median, as done in Card et al. (1999) and elsewhere, since in the present analysis wages are missing not only for non-workers, but also for self-employed and those employed who did not report their wage. Setting their wage to minimum wage would seriously underestimate the means, and even the medians, in cases where more than 50 % of the wages in the skill-group are missing (although these are quite rare).

[30] See Section A of the Appendix for details.

[31] The UK is an exception, as the data come from surveys conducted throughout the entire year. See Section A in the Appendix for the details.

[32] The reported wages refer to current wages in France and the UK (previous month and previous week respectively). However, they refer to the previous year in the US dataset.

4 Empirical Facts

4.1 Data Issues

The three national labor force surveys used in the present analysis are: *Enquête Emploi* (1990-2002) for France, *Labor Force Survey* (1993-2002) for the UK, and the *March CPS* (1990-2001) for the US. The details are given in Section A in the Appendix. The sample selected for the empirical analysis consist of non-institutionalized individuals between the ages of 25 and 54. Individuals under 25 and over 54 years of age are not included in the analysis, as there are too many institutional issues (such as length of education and early retirement legislature) that differ across the three countries and make them not directly comparable. Although these groups have an important share in the total labor market, I choose to avoid the potential impact of these institutional differences on the present analysis and focus exclusively on prime age individuals.[33] Students, conscripts and members of the Armed Forces are also excluded. The employment and the labor force participation rates are defined in the standard way: Employed individuals include the employed and the self-employed, as well as the unpaid family workers, and labor force participants are individuals who are either employed or unemployed (according to the ILO definition of unemployment). The wage information uses the hourly wage as the key measure.[34] The wages are reported gross of taxes in the US and the UK, but net of employees' payroll taxes in France. The present analysis uses the same argument for the validity of the cross-country differences as in Card, Kramarz, and Lemieux (1999, p. 857): the employees' payroll taxes in France are set at a fixed rate, and therefore should not affect the relative between-group wages which are the main focus of the analysis. For a more detailed discussion of this fact and the gross versus net wages differences in France, see Section A in the Appendix.

There are 72 skill groups (and 60 for the UK) defined in each dataset. The skill groups are based on gender, five age ranges (25-29, 30-34, 35-39, 40-44, 45-49 and 50-54) and six education categories in France and the US, and five education categories in the UK. Their classification is chosen so as to keep a reasonable size of all the skill-groups over all the years. The group sample size is never below 150 individuals.[35]

All the skill-groups are used together in the empirical analysis. This is in contrast with the estimation strategy in Card et al.(1999) who estimate their model separately by gender. As the theoretical model (although very stylized) is designed to describe the whole economy, and as it is likely that there is a non-zero substitution between men and women in many economic areas, I consider it appropriate to use everybody together in the estimation of the model.

The model does not distinguish between individuals of different ethnicity or immigration status, the reason being the absence of relevant comparable variable with this

[33] Prime age individuals who are out of school correspond to the "population" in the theoretical model presented in Section 2.

[34] See Section A in the Appendix for the description of the way the hourly wage has been constructed in the three datasets. A sensitivity analysis was performed on the reported weekly, monthly or annual wages (when the information was available) using the full-time workers only.

[35] See Table A.1 in the Appendix for details.

information in all three datasets.[36] The empirical analysis therefore ignores any race-based or immigration-based discrimination at the demand side or race or immigration heterogeneity in preferences at the supply side. The author considers this approach more appropriate than using only the sub-sample of Whites for the US (or potentially UK), as done in Card et al. (1999). The reason is, again, that the model is designed to describe the whole economy with all individuals and all the subgroups.[37]

4.2 Main Trends

This section surveys the main demographic developments and the key trends in the labor force status, wages and the supply and demand shifters for various subgroups of the the "out-of-school" non-institutionalized civilian population between the ages of 25 and 54 in the three countries between 1990 and 2002. The same three labor force surveys used in the empirical analysis are the source for the tables in this section.[38] Survey personal weights were used in the calculations of the presented summary statistics, so as to reflect population-wide developments.

The cross-country differences in labor force status by gender were already mentioned in the Introduction. As shown by Figure 3, the labor force participation rates of men and women converged together in all three countries (the participation rate of men decreased, while that of women increased): the early 90s gap of about 20 percentage points was reduced to about 15 percentage points twelve years later. In terms of levels, France had the highest labor force participation rates over the entire period, and the US the lowest (with men's rate about 5 percentage points and women's rate about 2 percentage points lower than in France). The decrease in the male labor force participation rate was about the same (2 percentage points) in all three countries,[39] while the increase in female rate was twice as high in France (about 6 percentage points) than in the other two countries (about 3 percentage points). Figure 2 suggests that employment was initially highest among French men; the male employment rate in the three countries then converged to the same level in the second half of the period. The high labor force participation rate of women in France is more than offset by the high proportion of the unemployed among French women: the female employment rate is the lowest in France (in the other two countries it is higher by almost 5 percentage points). The female employment rates increased at a similar pace in the three countries, while the employment rate of men decreased in France and the US in the first half of the period but remained more or less at the same level from there on. Figure 2 also reflects the aggregate development of the three economies. While the UK and the US were in an expansionary phase of the business cycle during the 1990s (starting in 1992 in the US and 1993 in the UK), in France most of the period was recessionary, with the economic recovery starting only in

[36] The French dataset does not have a variable with information about ethnicity, while the US dataset lacks any immigration status information in the early years of the analysis.

[37] The ethnicity and immigration status variables are used - where available - for the prediction of wages in the Heckman procedure.

[38] All three surveys are used by the national statistical offices of the three countries for constructing the official labor market statistics.

[39] Note that although France and UK show slow but steady trend of decrease, the labor force participation rate of men in the US fluctuates with a slight decrease in the early 2000s.

1998.

Figures B.1 through B.6 present the changes in the labor force status and earnings for the six (five in the UK) educational categories. All the figures are designed to capture best the between-group differences and their changes over time in each country and gender group specifically, and therefore they differ substantially in scale. Any cross-country comparisons of levels or changes require looking at the actual magnitudes. Figures B.1 through B.4 that show the employment and inactivity rates emphasize the difference between the least educated, i.e. education group 1 and 2 in the US (high-school dropouts: below 9th grade, and between 9th and 12th), group 1 in the UK (less than O-levels), and group 1 in France (no diploma or CEP), and the rest of the population in all three countries: the least skilled have substantially lower employment rates and higher inactivity rates than everybody else. Their employment rate is (at least in the US and France) also more sensitive to the business cycle than the employment rate of the other groups.

In terms of levels, the least skilled men in France remain better off in terms of employment rate and the relative wages (with respect to the most skilled) than their counterparts in the UK and in the US. The inactivity rate among the least skilled men is the highest in the US and the lowest in France during the entire period. The employment rate of the least skilled women is the highest in the UK, followed by France and the US. Correspondingly, their inactivity rate is higher in the US than in the other two countries. The relative wages of the least skilled women (with respect to the most-skilled) compare in the same way as those of men between the three countries.

In terms of changes, the employment of the least skilled men follows complete business cycle in the US, shows slight increase in the UK, and has a clearly decreasing trend in France. The inactivity rate among the least-skilled has increased in all three countries by similar amount of percentage points, keeping the substantial initial cross-country differences unchanged: the rate increased from 14 % to 20 % in the US,[40] from 11 % to 17 % in the UK, and from 6 % to 11 % in France. While the increase in inactivity in the US and the UK goes almost one to one with the decrease in unemployment, in France it exactly corresponds to the reduction in employment.[41] However, inactivity increases among the other education groups of men as well in all three countries. It is more pronounced among the low and middle educated men, so the inactivity rates between the different educational categories fan out over time.

The employment rate of the least skilled women has decreased over time in the UK, while it has slightly increased in the other two countries. These trends seem to be inversely mirrored by the inactivity rate. The inactivity among women in general shows slight decline in all three countries with the exception of that of the least skilled women in the UK, which increases over the entire period, as well as the low-skilled in France, and the highest-skilled in the US, which slightly increases in the later years. However, the between-group differences among women have not increased as much as for men, and

[40] There is also a cyclical increase and decrease at the beginning of the period in the inactivity rate of the very least skilled (group 1) in the US that goes as far as above 25 %.

[41] The "sudden" rise in inactivity after 1996 may be related to the policy measures that have enacted the possibility and increased the incentives of early retirement in order to enhance job availability for younger workers ("the early retirement for job scheme"). However, looking at the least skilled by the different age groups shows some increases in inactivity across all ages.

in the US they have actually decreased.[42]

In the US, the real wages has fanned out substantially over the entire period, with the ratio of the mean hourly wage of the highest education group to that of the lowest increasing from 2.55 to 3.5 for men and from 2.7 to 3.05 for women. It was mostly the rapid increase in the wages of the high educated that caused this rise in the between group inequality, as the wages of the least-skilled stagnated (or only slightly increased for women). The between-group wage differences declined in the other two countries: the highest-lowest education group ratio decreased from 2.16 to 2.15 for men and from 2.4 to 2.21 for women in the UK, and from 2.14 to 1.93 for men and 2.34 to 2.02 for women in France.[43] The real wages have increased over the entire period for all education groups in the UK, among the high-educated in the US and among the low-educated in France. The beginning of the steeper growth in the wages of the least-skilled in the UK coincides with the introduction of the minimum wage in April 1999 and its subsequent increases. The automatically adjusted minimum wage in France (indexed to wage inflation) and the presence of collective bargaining is likely to account for the wage increases among the low-skilled in this country.[44]

To summarize: The employment of the low-skilled in France has deteriorated, while their real wages have increased. The employment rate of the low-skilled in the UK has been more or less stagnant (it has slightly risen for low-skilled men but decreased for low-skilled women), while their wages have also gone up; however, when measured relative to the high-educated, less so than in France. The employment rate of the low-skilled in the US increased after 1996 with the economy's boom but has not reached the initial level of 1990. The wages remained more or less constant for men and have risen only slightly for women. The relative wages of the low-skilled (with respect to the high-educated) have substantially decreased. While the between-group variation in wages has increased in the US, the employment rates of the educational groups have come closer together.[45] However, the male inactivity rates have continued to fan out. In the UK, the between-group differences in wages and employment have stayed more or less the same, while in France it was the wages that got closer together and the employment rates that diverged. In both countries, inactivity has fanned out for both men and women.

The employment rate, the inactivity rate and the earnings for the six age groups (not presented in the paper) show very similar patterns across all three countries: for women, employment has increased and inactivity decreased in all age groups but most among the

[42] This may be due to the fact that the long-term increase in labor force participation of women extends further among the less educated and possibly counteracts any general inactivity increases among the low-skilled. The trend may also be a consequence of the increase in inactivity / unemployment of men (an added worker hypothesis).

[43] The ratios might be slightly higher and the decrease smaller if the information on gross wages was available. Although the pay-roll taxes in France are a fixed proportion, there are top ceilings up to which the percentage applies. There is also a minimum wage level below which the tax does not apply. However, it is the case that majority of the population is in between the two limits. Unfortunately, all the wage inequality statistics available for France (such as the OECD measures) that I could find to compare my estimates against, were based on wages net of the payroll taxes.

[44] However, again, part of the increase may be also due to the reduction in the relative effective payroll taxes paid by the high educated versus the low educated.

[45] This might be partially due to an economy's boom which typically has higher impact on the employment of the low-skilled as compared with the high-skilled.

old; both the employment rates and the inactivity rates among different age groups of women have therefore converged together over the period. The employment rate among men for all age groups has increased in the UK, while it has decreased and followed the business cycle in France and the US. The employment of the 50-54 age old men has decreased most, while their inactivity has risen most sharply in all three countries. The wage rates have increased at a similar pace[46] across all age groups in all three countries both for men and women, but at a higher rate for the latter.[47]

The present analysis is trying to explore what stood behind these developments. Did the skill-biased technological progress continue to hurt the low-skilled in all three countries and (assuming its similar demand effects across countries) resulted - in accord with the trade-off hypothesis - in the decrease of low-skilled employment in France (a country with low wage flexibility), while their relative wages were pushed up by the minimum wage and the collective bargaining,[48] and in the decrease of the relative wages of the low-skilled in the US (a country with flexible wages), while the trend in employment remained stable there? Did the enactment of the minimum wage in the UK and its rise in presence of the skill-biased technological progress hurt more the low-skilled women (as their employment rate decreased) than low-skilled men? Is the rise in male (and in the UK also female) inactivity among the low-skilled a result of the negative effect of the relative wage deterioration on the labor supply (as suggested by the extended trade-off hypothesis), or a direct consequence of the negative shift labor demand that makes the low-skilled unemployed, which cannot find any jobs, to leave the labor force? To what extent is the rise in male inactivity a purely supply side phenomenon, caused by the increasing role of men at home and child-care, or by the increase in the preference for leisure (such as the early retirement decision)? These are the questions that the present work is interested in.

As for the demographic changes, the long-term trends continued also in the years 1990-2002: the populations of all three countries became older (age structure changed in favor of the older groups), more educated, and the timing of marriage and child-bearing is postponed to later ages. The proportion of the first three age groups in the total prime age population shifted from 56 % to 49 % in the US, from 55 % to 49 % in France, and from 54 % to 51 % in the UK over the given period. In the US, the proportion in the three lowest education groups decreased from 26 % to 22 % among men and from 29 % to 21 % among women, while the proportion of the other three education groups have increased. In France, the same proportion changed from 36 % to 31 % among men and from 36 % to 29 % among women, while in the UK, it was from 38 % to 35 % among men and from 40 % to 37 % among women. The education structure therefore changed most rapidly in France, followed by the US, and only then the UK. The proportion of married individuals decreased in all age categories in all three countries with the highest decrease in the 25-29 age range, followed by the 30-34 age range. The biggest decrease occurred in France where the initial rates were also the lowest, while the smallest change happened

[46] In the US and the UK, the rate was somewhat slower for the oldest age group 50-54.

[47] Thus wages of men and women converged in all age groups, with female wages still remaining below the wages of men.

[48] There is however an alternative explanation for the observed decrease in employment and rise in wages of the low skilled in France, and that is a negative shift in their labor supply.

in the US, where the initial rates were also the highest. Child-bearing decreased among both men and women between the ages 25-29, while increasing in the later two groups (30-39) in all three countries. Again, this demographic trend was strongest in France, and least pronounced in the US.

As for the demand shifter, it clearly declined for the low-skilled groups in all three countries. Although there is - by construction - some correlation between the proportion of these groups in population and the demand index, the negative trend continues even after the index has been weighted appropriately to purge out the population effects. The change is similar for the three low-educated groups of men across the three countries (about 1 % population-weighted decrease), while for the low educated women, the change is positive (about 1 % population-weighted increase) in the US and the UK, while there is only about 0.1 % negative change for the low-skilled women in France. The data therefore suggest that the change in demand for the low-skilled was (at least in the UK and the US) more favorable to women than to men.

5 Estimation Results

5.1 Reduced Form Estimates

I first survey and interpret the results from the reduced form estimation of the system of the three equations 12, 13, and 14. Tables 1 and 2 show the results for the preferred specification that employes the mean of the real hourly wages in the skill-group as the left-hand-side wage variable. Table 1 constructs the wage as the mean of the observed wages, while Table 2 utilizes wages of all the individuals, using predicted wages when the actual wage is not observed.[49] The rest of the group-level variables are constructed from the individual-level data as the weighted group proportions or means, using the survey probability weights. Results were obtained by joint estimation of the three equations using the transformed, heteroskedasticity weighted, group-level variables.

The trade-off hypothesis suggests that wages should be more sensitive to the changes in the demand and supply in the US and the UK, countries where wages are flexible, than in France. The opposite should be true for the employment rate. This is only weakly supported by the results: The responsiveness of wage to the demand shifter does not significantly differ across the three countries. As Table 3 shows, the t-statistics of the difference between any pair of the coefficients across the three countries is always below the 5 % significance threshold except for one case: the US coefficient of 0.12 is significantly higher than the French coefficient of 0.07 when both observed and predicted wages are used for the construction of the skill-group wages. However, the coefficient of the demand shifter in the employment equation in France is significantly different from the coefficients in the other two countries. The responsiveness of employment to the exogenous changes in the demand is much higher in France (0.10) than in the UK (0.4) or the US (0.2); the latter two coefficients are neither significant, nor significantly

[49] As the two specifications alternate only the construction of the wage variable, the results in the two Tables differ primarily in the estimation of the wage equation; the coefficient estimates from the other two equations are almost identical.

Table 1: Reduced Form Estimation Results Using the Mean of the Observed Wages (Heteroskedasticity-Weighted)

		France 1990-2002			UK 1993-2002			US 1990-2001		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.12	0.014	-8.54	-0.06	0.041	-1.51	-0.07	0.020	-3.70
	married F	-0.32	0.066	-4.80	-0.10	0.082	-1.22	0.08	0.070	1.11
	married M	-0.04	0.060	-0.60	0.42	0.101	4.13	0.64	0.061	10.56
	child6 F	-0.01	0.048	-0.18	0.22	0.118	1.87	0.19	0.098	1.96
	child6 M	0.15	0.049	3.11	-0.01	0.102	-0.05	-0.14	0.097	-1.42
	D shifter	0.06	0.012	4.93	0.03	0.040	0.84	0.08	0.019	4.47
E	lngpop	-0.06	0.010	-5.90	-0.04	0.023	-1.53	-0.03	0.014	-2.24
	married F	-0.27	0.064	-4.20	0.07	0.059	1.11	-0.21	0.061	-3.38
	married M	0.10	0.038	2.71	0.16	0.049	3.37	0.21	0.036	5.95
	child6 F	-0.04	0.046	-0.84	-0.40	0.092	-4.39	-0.21	0.090	-2.32
	child6 M	0.11	0.026	4.26	-0.10	0.046	-2.05	0.01	0.050	0.11
	D shifter	0.10	0.010	10.50	0.04	0.023	1.54	0.02	0.013	1.25
LS	lngpop	-0.04	0.006	-6.08	-0.06	0.016	-3.88	-0.04	0.011	-3.53
	married F	-0.34	0.047	-7.23	-0.15	0.054	-2.79	-0.25	0.055	-4.63
	married M	0.07	0.019	3.82	0.04	0.031	1.23	0.22	0.028	7.80
	child6 F	-0.06	0.034	-1.89	-0.33	0.085	-3.85	-0.14	0.081	-1.71
	child6 M	-0.01	0.012	-0.94	-0.03	0.029	-0.95	-0.06	0.037	-1.58
	D shifter	0.06	0.006	9.08	0.09	0.016	5.27	0.04	0.011	3.45

Note: Variables are first transformed by appropriate weights (see Section E.1 of the Appendix), so as to eliminate the group-wise heteroskedasticity. The three equations - wage equation (W), employment equation (E) and labor force participation equation (LS) - are estimated jointly. The LHS variable of the wage equation is the logarithm of the *mean* of the observed real hourly wages (CPI base year 1995). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. Table 3 presents the t-statistics of the cross-country differences between the corresponding reduced form coefficient estimates from Tables 1 and 2. The rest of the group-level variables were constructed from the individual data (weighted with the survey probability weights) as the group proportions or means.

Table 2: Reduced Form Estimation Results Using the Mean of the Observed and Predicted Wages (Heteroskedasticity-Weighted)

		France 1990-2002			UK 1993-2002			US 1990-2001		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.10	0.013	-7.79	-0.06	0.035	-1.76	-0.10	0.018	-5.40
	married F	-0.16	0.061	-2.67	0.19	0.069	2.75	-0.09	0.064	-1.46
	married M	-0.30	0.055	-5.53	0.03	0.088	0.35	0.82	0.055	14.76
	child6 F	0.02	0.044	0.48	0.04	0.099	0.37	0.22	0.089	2.46
	child6 M	0.15	0.045	3.28	0.04	0.089	0.44	-0.32	0.088	-3.67
	D shifter	0.07	0.011	5.89	0.07	0.035	1.89	0.12	0.017	6.68
E	lngpop	-0.06	0.010	-6.04	-0.03	0.023	-1.45	-0.03	0.014	-2.19
	married F	-0.27	0.064	-4.15	0.06	0.059	1.06	-0.21	0.061	-3.36
	married M	0.10	0.038	2.52	0.15	0.049	3.13	0.21	0.036	6.04
	child6 F	-0.04	0.046	-0.77	-0.40	0.091	-4.34	-0.21	0.090	-2.30
	child6 M	0.11	0.026	4.25	-0.10	0.046	-2.07	0.00	0.050	0.08
	D shifter	0.10	0.010	10.67	0.04	0.023	1.53	0.02	0.013	1.22
LS	lngpop	-0.04	0.006	-6.15	-0.06	0.016	-3.77	-0.04	0.011	-3.34
	married F	-0.34	0.047	-7.20	-0.15	0.054	-2.86	-0.25	0.055	-4.63
	married M	0.08	0.019	3.87	0.03	0.031	0.92	0.22	0.028	8.01
	child6 F	-0.06	0.034	-1.85	-0.32	0.085	-3.82	-0.14	0.081	-1.78
	child6 M	-0.01	0.012	-0.92	-0.03	0.029	-1.02	-0.07	0.037	-1.81
	D shifter	0.06	0.006	9.12	0.09	0.016	5.28	0.04	0.011	3.34

Note: Variables are first transformed by appropriate weights (see Section E.1 of the Appendix), so as to eliminate the group-wise heteroskedasticity. The three equations - wage equation (W), employment equation (E) and labor force participation equation (LS) - are estimated jointly. The LHS variable of the wage equation is the logarithm of the *mean* of the real hourly wages (CPI base year 1995) of all the individuals in the skill-group. Wages of individuals who are not working or other missing wages are predicted using the two-equation Heckman model estimated jointly by maximum likelihood (see Section E.2 of the Appendix). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. The rest of the group-level variables were constructed from the individual data (weighted with the survey probability weights) as the group proportions or means.

Table 3: Significance of the Cross-Country Differences in the Reduced Form Coefficient Estimates (t-statistics)

		Observed W			**Observed and Predicted W**		
		FR vs UK	FR vs US	UK vs US	FR vs UK	FR vs US	UK vs US
W	lngpop	-1.32	-1.81	0.28	-1.02	-0.04	0.94
	married F	-2.08	-4.10	-1.65	-3.83	-0.79	3.01
	married M	-3.86	-7.95	-1.90	-3.24	-14.36	-7.58
	child6 F	-1.80	-1.84	0.20	-0.15	-2.00	-1.36
	child6 M	1.40	2.68	0.94	1.09	4.77	2.90
	D shifter	0.61	-1.12	-1.14	0.00	-2.42	-1.28
E	lngpop	-1.04	-1.81	-0.18	-1.18	-1.93	-0.13
	married F	-3.83	-0.69	3.20	-3.76	-0.67	3.14
	married M	-1.00	-2.10	-0.80	-0.92	-2.30	-1.05
	child6 F	3.55	1.69	-1.50	3.54	1.70	-1.48
	child6 M	3.87	1.88	-1.48	3.88	1.90	-1.47
	D shifter	2.67	5.13	0.70	2.74	5.25	0.70
LS	lngpop	1.45	0.10	-1.22	1.32	-0.10	-1.23
	married F	-2.68	-1.22	1.35	-2.61	-1.20	1.30
	married M	0.97	-4.20	-4.25	1.27	-4.34	-4.63
	child6 F	2.88	0.86	-1.59	2.86	0.93	-1.52
	child6 M	0.52	1.22	0.65	0.59	1.44	0.79
	D shifter	-1.73	1.42	2.44	-1.71	1.54	2.50

Note: The presented numbers are the t-statistics of the cross-country differences between the corresponding reduced form coefficient estimates. The t-statistics determining the significance of the difference between the estimate of some coefficient β with variance σ for country A and the corresponding estimate for country B is computed as $t = \frac{\hat{\beta}_A - \hat{\beta}_B}{\sqrt{\hat{\sigma}_A^2 + \hat{\sigma}_B^2}}$; independence is assumed between estimates from different countries. The first three columns present the t-statistics for the differences between the estimates from Table 1, the next three column for the differences between the estimates from Table 2.

different from each other. This is the only finding from the reduced form estimates in support of the original trade-off hypothesis. The comparison of the sensitivity of wage and employment to the supply shifters across the three countries does not provide any further evidence. The coefficients of the logarithm of the proportion of the skill-group in the population are very similar across the three countries in all three equations (the difference is never significant at the 5 % level). Although the coefficients of the other supply shifters are often significantly different and vary substantially in magnitude across the three countries, they do not exhibit any systematic differences in support of the hypothesis.

The extended trade-off hypothesis (the original trade-off hypothesis extended to what happens to labor supply and inactivity) finds also some supporting evidence: The demand shifters affect the labor force participation less than the proportion in employment in France, while it is the other way round in the other two countries: the demand effect on labor force participation in the US and the UK is both significant and larger than on the employment proportion (presumably working through the negative effect of demand shifts on wages). However, the within country difference between the demand shifter coefficients in the employment and in the labor force participation equations is significant only in France.[50]

Before computing the structural parameters, I first check the empirical validity of the model by exploring the signs of the reduced form coefficients from the perspective of their corresponding structural content, as described in Table D.1 in the Appendix. The signs of the estimated reduced form coefficients seem to be more or less consistent with the predictions of the theoretical model. As σ, ε and ρ are all assumed greater than zero and the term $\frac{\sigma\rho}{\sigma+\varepsilon}$ is likely to be smaller than one,[51] the coefficient of the logarithm of the group's proportion in the population is expected to be negative in all three equations, and this is the case for all three countries and under all specifications. If, in addition, σ is assumed to be greater than one (as has to be the case in order to assure a positive effect of the relative efficiency parameters on the labor demand), the coefficients of the demand shifters should be all positive, which again is true for all countries and equations under all specifications.

Projecting the structural parameters to the other supply shifters suggests that their signs in the employment and labor force participation equation should correspond to the sign of their structural counterparts, while in the wage equation they have an opposite sign. The structural sign of the labor supply effect of presence of pre-school children in the household on the labor force participation of women is negative, as it empirically should be, in all three countries.[52] The implied structural effect of children on the labor force participation of men has mixed signs and it is significant at the 5 % level only in the wage equation in the US (for the specification that uses both the observed and the predicted wages), where it implies a positive effect, and in the wage and the employment

[50] The t-statistics is not presented here, but its upper bound, as the covariances between these two coefficients are positive for all three countries, can be easily calculated from Table 3 using the formula for two independent estimates.

[51] The reason being that ε is positive and ρ should not exceed one.

[52] The only exception is France for the specification that uses the observed wages (Table 1.) The coefficient in the wage equation implies a positive sign, but it is not significant.

equations in France, where the two estimates suggest opposite structural effects. The results for the effects of the marital status are even less clear.[53] As described later in this section, structural estimates offer a more consistent picture of the effects of the two exogenous supply shifters.

Section C in the Appendix includes results from the other specifications. Tables C.3 and C.4 present the results when the median of the observed or predicted wages is used instead of the mean. Tables C.1, C.2, C.5 and C.6 show the un-weighted results, when the variables are not adjusted for heteroskedasticity. The sensitivity analysis shows that in terms of signs and significance the results are fairly robust. However, the other specifications provide even less support for the trade-off hypothesis than the preferred results presented in this section.

5.2 Counterfactual Simulations

The reduced form results were used to construct counterfactual series holding the supply or the demand shifters constant in order to show what would have happened had there been no exogenous changes in the supply or demand respectively. A comparison of the actual and the simulated series reveals what factors stood behind the development in earnings and labor force status in different skill-groups in the three countries, and which of these factors have dominated. These simulations are presented in Figures B.7 to B.24 in the Appendix.[54] First, in-sample prediction was performed where the estimated reduced form model is used to predict the earnings and labor force status of the respective skill-groups. Second, two counterfactual series were generated to separate the effect of exogenous changes in the supply and the demand respectively. In this simulation exercise, earnings and labor force status of each skill-group are predicted using the estimated reduced form coefficients, while holding the demand or supply shifter constant at its value at the beginning of the period. The two simulated series thus represent the counterfactual evidence suggested by the model of how earnings and labor force status of the respective groups would have evolved had there been no exogenous shifts in the demand or supply respectively.

Although the prediction and the simulation assign each particular gender-education-age-specific skill-group in each year a specific predicted or simulated value of the left-hand side variable (i.e. earnings or labor force status), for the sake of exposition the results

[53] It might be the case that the variables are not measured or defined adequately enough to correspond to what they are supposed to describe. As already mentioned, it is not necessarily the fact that the person has her or his own pre-school children but only that there is at least one pre-school children present in the household. Marital status here describes either married individuals with spouse present or individuals that cohabitate in a couple with a another person.

[54] The simulation is based on the reduced form estimates from the specification which uses the mean of the observed hourly wages and does not weigh the variables to account for heteroskedasticity. See Table C.1 in the Appendix. The specification which uses only the mean of the observed wages was chosen to allow a direct comparison of the predicted and the simulated results with the actual series. Results that do not take into account the cross-group heteroskedasticity were selected, so as to avoid the potential effect of the transformation of the variables by weights (in particular the weighting of the shifters in the counterfactual exercise where they are held constant) on the main developments in the data.

are grouped and presented by gender and education only.[55] Each plot includes four series: the actual values, the in-sample predicted values, and the two sets of simulated values. The first simulated series shows what would have happened had the demand shifter stayed at its initial level over the entire period, the second series presents how the variable would have evolved had there been no changes in one of the supply shifters, namely the fraction of a skill-group in the population. The actual and the predicted series show that the in-sample prediction is reasonably close to what actually happened to earnings and labor force status over the analyzed period.

The results suggest that both demand and supply changes were in effect over the period in all three countries. Two key trends in the exogenous changes of demand and supply are common to the three countries. The distribution of the population across the different education groups shifted from the low educated towards the most educated: the exogenous supply shifter defined as the fraction of a skill-group in a population was declining for the less educated and increased for the more educated. Other things being equal, this development would have pushed wages and employment rate among the low-educated up, and their inactivity rate down, while generating a downward pressure on wages and employment rate of the high educated, and an upward pressure on their inactivity rate. The exogenous demand structure exhibited an opposite development: the demand shifter was falling for most of the low-educated groups, while it was rising for the more educated. Had there been no changes in the supply (i.e. no changes in the skill structure of the population) the exogenous changes in the demand would have pushed wages and employment rate of the low-educated down, thus increasing their inactivity rate, and it would have pushed the wages and employment rate of the more educated up, thus reducing their inactivity rate. In other words, the impact of the changes in the supply has been counteracted by the impact of the changes at the demand side, going in the opposite direction. The earnings and labor force status development for the respective education groups in the three countries differ only in the relative strength of the two factors.

Figures B.7 to B.9 show that the cross-country differences in the evolution of the employment rate of men were dominated by the aggregate development of the three economies. While the UK and the US were in an expansionary phase of the business cycle over the 1990s (starting in 1992 in the US and 1993 in the UK), for France most of the period was recessionary, with the economic recovery starting only in 1998. Accordingly, employment rates in the US and the UK were rising in all education categories, while in France they were falling in most years. Using the simulated series, we can identify what impact the demand and supply factors for the different countries had on the aggregate development, i.e. whether it slowed down or rather sped up the male employment rate rise in the US and the UK and the male employment rate decline in France across the different skill-groups.

Figures B.7 and B.16 show that the demand factors dominated the evolution of the group-specific employment rates in France. This is true in particular for French men. The counterfactual evidence predicted from the reduced form model suggests that had the

[55] The values by gender and education are constructed as a weighted sum of the group-specific (i.e. gender-age-education) values, using relative population shares of different age groups as weights.

demand structure stayed the same, employment of the more educated men would have declined, while employment of the least skilled men would have stayed more or less the same. The employment rates across the education groups would have converged rather than diverged. Had there been no change in the supply, the demand changes would have affected the employment rates more drastically: the employment rate of the least skilled would have declined more sharply and all the rates for the different education groups would have fanned out more broadly than they actually did. The increase in the fraction of the most educated in the population was only partially absorbed by the favorable demand changes for the high skilled. Although the results for French women are similar, the demand shifts were less harmful and the supply shifts were more favorable among low educated women, which explains why their employment rate remained at the same level most of the time and even increased at the end of the period.

Figures B.8 and B.17 show that the adverse effect of the demand on the employment rate of the low educated was more than mitigated by compensating changes in the supply. On the other hand, an increase in the supply shifter of the most skilled partially counteracted the favorable demand changes among these groups. Overall, in the UK the supply changes were more important for the evolution of the employment rates than they were in France. However, even in the UK the supply side effects were often offset by the opposite impact of the demand shift.

In the US, as shown on Figures B.9 and B.18, demand factors dominated the evolution of the employment rate of the low educated in the first half of the period, while supply shifts were more important in the second half. Among the high educated, exogenous changes in the supply more than mitigated the demand changes. The results for the US show divergent developments of two education groups, namely the high school graduates (ED3) against the high school graduates with some college or some further education other than college (ED4). It is clear that the demand shifted away from the less educated group towards individuals who had spent some time getting education after high school. The figures show that these changes in the demand structure were almost perfectly complemented by an opposite development at the supply side: the fraction of people with some education after high school increased substantially, thus reducing the population fraction of high school graduates. It is between these two groups that the effects of the exogenous supply and demand changes reverse the sign, i.e. change the direction in between the way they affect the low educated and the way they affect the high educated.

Overall, demand factors dominated the supply side effects in the development of the employment rates in France, thus favoring the high educated and harming the low educated: the employment rates among the low educated declined more than those of the high educated. The impact of the supply and the demand factors on the employment rates in the UK were more or less balanced, with the supply effects dominating among the least and the most educated. The simulated decline in the employment rate of the least educated was reversed by the favorable supply changes, thus resulting in an increase of the employment rate among the least skilled. The exogenously increasing supply of the high educated slowed down the growth of their employment rates, as driven by the favorable demand changes. In the US, it was the exogenous changes in the supply that were stronger. This resulted in a more rapid growth in employment rates among the low educated and a slower growth of the employment rates among the high educated than would have happened had there been only exogenous shifts in the demand.

Inactivity rate increased among the low educated men and stagnated among the high-educated men in France and the UK. Figures B.10 and B.11 show that this development was driven by changes in the demand that reversed the effect of the changes of the population's skill structure on the supply side. In the US the decrease in the inactivity rate of the least educated and the slow rise in the inactivity rate among the high educated were clearly supply driven.

Figures B.15 and B.24 show that in the US the effect on wages of supply and demand changes, as represented by the simulated counterfactual series was negligible in the face of the rise in the real hourly wage rates across all the education groups that started around 1996. Figures B.14 and B.23 show similar development for the UK, where the beginning of the wage growth occurred around 1999. The overall wage increase in the two countries can be attributed to the expansionary phase of the business cycle but also to institutional changes in the minimum wage. In 1996, minimum wage was increased in the US, after it had been held at the same level for a number of years. In 1999, the UK enacted national minimum wage for the first time in history. Further increases in the minimum wage followed in both countries. It seems likely that changes in the minimum wage pushed the entire wage distributions upwards, although favoring the most those with the lowest wages. Yet we can see, in particular among the high educated in the UK, that the demand changes would have increased wages of the high educated even more had it not been for the positive shifts in their supply. The opposite holds for the less educated. In France, as shown on Figures B.13 and B.22, real hourly wages across all the education groups followed a much more cyclical pattern than in the other two countries. Furthermore, it was the wages of the low educated that have eventually risen the most, while the wage levels of the high educated stayed more or less the same, or even declined. The eventual rise across all education categories coincides with the adoption of the common European currency (EURO) in 1999. The effects of the exogenous demand and supply shifts are much more visible here than in the other two countries. The two figures suggest that the evolution of wages in France was dominated by the changes in the supply rather than those in the demand. Had there been no exogenous changes in the supply, the wages of the low educated would have increased less, and the wages of the high educated would have first declined less and then increased more than they did. The figures also show that the wages of the least educated increased even more than they would have according to the model if supply changes were exclusively at play. This reflects the effect of minimum wage and, possibly, collective bargaining that pushed the wages at the bottom of the wage distribution up irrespective of the market forces.

In accord with the reduced form coefficient estimates, the simulation results provide some evidence for both the standard trade-off hypothesis and its extended version. The decline in the employment rate of the low educated in France at a time when their relative and absolute wages were rising was the result of negative demand shifts in the face of wages that were pushed up by institutions, rather than a consequence of a negative supply shift. The effect of the shifts in supply that caused the inactivity of the least educated in the US to decline could reflect the fact that the low educated were more attracted to the labor force through the positive effect of these supply changes on wages. However, contrary to what the trade-off hypothesis would suggest, wages were not adjusting very substantively to the exogenous demand or supply changes in any of the three countries, whereas the employment and inactivity rates did. Also, the increase in the inactivity rate among the low educated in France and the UK was demand driven, as suggested by the simulated counterfactual evidence, despite the fact that the absolute and the relative wages in these groups increased. This suggests that demand had a direct effect on inactivity in addition to the effect through wages. This effect is not part of the simple labor supply and labor demand model estimated in the present analysis. It would require adding additional features, and taking into account the phenomenon of the discouraged worker as well as the effect of the welfare system on the distribution of non-employed between unemployed and inactive to capture the direct effect of the demand on inactivity.

5.3 Structural Estimates

Generalized method of moments was employed next in order to recover the structural parameters from the reduced form estimates. This method, also known in this context as optimal minimum distance method or OMD, makes use of all the estimated reduced form coefficients at the same time, assigning them optimal weights that reflect the precision with which they were estimated. I also present the results when equal weights are assigned to all the moments, a method sometimes called equally weighted minimum distance estimation or EWMD. See Section E.3 in the Appendix for details. The structural results, attained by using EWMD and OMD methods, and based on the reduced form results from Tables 1 and 2 are presented in Tables 4 and 5.

The value of the criterion function which is minimized in the OMD method is distributed according to a $\chi 2$ distribution with the appropriate number of degrees of freedom, and provides a goodness-of-fit statistics for the models. As discussed in Section E.3 in the Appendix, there are 11 degrees of freedom in the present estimation, as 7 structural parameters are computed from 18 moments. As $\chi 2_{11} = 19.68$ at the 5% significance level, none of the models for any of the specifications is rejected, which suggests that the theoretical model fits the data reasonably well.

Most of the coefficients have reasonable signs and magnitudes consistent with the theoretical model. The values of σ range from 1.66 to 2.0 and they are always highly significant. The interpretation of this parameters is not straightforward even within the theoretical framework of the model. The CES production function implies that σ is both the elasticity of substitution between any two of the groups, but also the wage elasticity of the labor demand. In addition, the theoretical model requires σ to be greater than one in order to assure a positive effect of the relative efficiency parameters on the labor demand (see equation 3); however, this contradicts established empirical findings which suggest that wage elasticity of labor demand is smaller than one. The wage elasticity of labor supply ranges from 0.07 to 0.23 and is also always significant.[56] The values of

[56] This order of magnitude is consistent with the author's previous findings (see the first chapter of this dissertation). The values are not directly comparable to the usual findings of the wage elasticity of labor supply, as this is an "averaged" estimate (across gender, age and education), common to all the skill-groups, of the wage elasticity of labor force participation (rather than labor supply of hours of

Table 4:
Structural Parameters Based on the Reduced Form Estimates from Table 1

	FR 1990-2002			**UK 1993-2002**			**US 1990-2001**		
	coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
EWMD									
σ	1.78	0.008	227.90	1.66	0.018	94.60	1.76	0.017	103.89
ε	0.09	0.014	6.04	0.23	0.016	14.42	0.11	0.038	2.92
ρ	0.76	0.007	109.61	0.85	0.009	96.82	0.82	0.030	27.72
β^f	-0.24	0.046	-5.31	-0.03	0.007	-3.71	-0.26	0.031	-8.30
β^m	0.10	0.019	5.36	-0.02	0.008	-2.69	0.05	0.019	2.74
γ^f	-0.05	0.033	-1.59	-0.44	0.006	-76.40	-0.22	0.005	-43.02
γ^m	0.00	0.011	0.38	-0.06	0.005	-11.61	0.01	0.009	0.74
q	0.44			0.54			0.80		
OMD									
σ	1.80	0.009	212.31	1.93	0.019	104.47	1.95	0.021	91.00
ε	0.12	0.013	9.41	0.07	0.012	6.33	0.14	0.043	3.38
ρ	0.89	0.007	127.03	0.98	0.007	150.15	0.74	0.027	27.34
β^f	-0.13	0.047	-2.80	-0.10	0.005	-18.04	-0.34	0.033	-10.45
β^m	0.10	0.019	4.93	0.09	0.006	15.20	0.30	0.020	15.00
γ^f	-0.08	0.034	-2.32	-0.34	0.004	-84.68	-0.14	0.005	-29.10
γ^m	-0.04	0.012	-3.71	-0.05	0.004	-11.67	-0.05	0.010	-4.94
$q \sim \chi^2_{11}$	1.26			0.76			0.54		

Note: The coefficients of the variables (group and year fixed effects estimates are not utilized in the method of moments) from the three equations (18 estimated parameters) are used to compute the structural parameters of the model. Numerical stability of the results requires that restriction be imposed on the parameter that maps the relative efficiency coefficient to its instrument - this parameter is set to one ($\lambda_1 = 1$). EWMD stands for equally weighted minimum distance method which uses identity matrix as the weighting matrix. OMD stands for optimal minimum distance method (or GMM) which uses the inverse of the covariance matrix of the six estimated coefficients as the weighting matrix. The initial values of the structural parameters in all three countries are set to one for the EWMD method and to the EWMD estimates for the OMD method. Standard errors were calculated by the delta method.

Table 5:
Structural Parameters Based on the Reduced Form Estimates from Table 2

	FR 1990-2002			**UK 1993-2002**			**US 1990-2001**		
	coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
EWMD									
σ	1.73	0.008	228.24	1.79	0.016	112.26	1.79	0.015	117.71
ε	0.11	0.013	8.48	0.20	0.015	13.36	0.10	0.036	2.89
ρ	0.77	0.006	119.75	0.85	0.008	110.87	0.84	0.027	30.85
β^f	-0.28	0.045	-6.16	-0.11	0.007	-16.58	-0.21	0.029	-7.16
β^m	0.17	0.019	8.91	0.08	0.007	11.34	0.01	0.019	0.62
γ^f	-0.06	0.033	-1.77	-0.38	0.005	-76.52	-0.23	0.005	-44.96
γ^m	0.00	0.011	0.41	-0.07	0.005	-14.92	0.05	0.009	5.56
q	0.40			0.36			1.15		
OMD									
σ	1.86	0.009	215.88	2.00	0.016	124.28	1.96	0.020	98.45
ε	0.19	0.015	12.36	0.08	0.011	6.73	0.16	0.043	3.67
ρ	0.86	0.007	125.91	0.98	0.006	160.66	0.73	0.025	28.76
β^f	-0.21	0.047	-4.51	-0.10	0.005	-18.98	-0.31	0.033	-9.45
β^m	0.10	0.020	5.22	0.08	0.006	14.05	0.30	0.020	15.33
γ^f	-0.08	0.034	-2.26	-0.33	0.004	-83.15	-0.15	0.005	-30.08
γ^m	-0.05	0.012	-3.78	-0.05	0.004	-11.36	-0.06	0.010	-5.84
$q \sim \chi^2_{11}$	1.28			0.75			0.71		

Note: The coefficients of the variables (group and year fixed effects estimates are not utilized in the method of moments) from the three equations (18 estimated parameters) are used to compute the structural parameters of the model. Numerical stability of the results requires that restriction be imposed on the parameter that maps the relative efficiency coefficient to its instrument - this parameter is set to one ($\lambda_1 = 1$). EWMD stands for equally weighted minimum distance method which uses identity matrix as the weighting matrix. OMD stands for optimal minimum distance method (or GMM) which uses the inverse of the covariance matrix of the six estimated coefficients as the weighting matrix. The initial values of the structural parameters in all three countries are set to one for the EWMD method and to the EWMD estimates for the OMD method. Standard errors were calculated by the delta method.

the wage flexibility parameter ρ range from 0.73 to 0.98 and again are always highly significant. The effect of marital status on female labor supply is always negative and significant, ranging from -0.03 to -0.34. The effect of marital status on man is mostly significant and almost always positive with values between 0.01 and 0.30. These results are consistent with previous empirical findings: marital status reduces the labor supply of women but increases that of men. The effect of the presence of children on female labor supply is always negative, significant and ranges from -0.05 to -0.44. The only exception is France, where it is not significant at the 5 % level when EWMD is used for the estimation. The effect of the presence of children on male labor supply is small and negative in most cases, and sometimes not significant at the 5 % level.

Although the structural estimates fall into reasonable ranges, the actual magnitudes vary substantially across different countries and different specifications. The cross-country differences between the key structural parameters are almost always significant, as the coefficients are almost never the same and they are estimated with relatively high precision, i.e. have very small standard errors. However, the cross-country comparisons vary - especially between the two methods (EWMD and OMD) - to such an extent that it is not easy to draw any strong conclusion about how the three different economies compare. The results in the two Tables 4 and 5 are fairly similar, suggesting that the findings are robust to the way the wage variables is constructed. In what follows, I focus on the results from Table 5 which takes into account the selection to employment bias when constructing the mean wages.

The comparison of the results for France and the UK is robust to the choice of the method (EWMD or OMD) except for the coefficient of the wage elasticity of labor supply: the EWMD suggests that it is greater in the UK (0.20) than in France (0.11), while OMD shows the opposite with the value equal to 0.19 in France and 0.08 in the UK. The results for the other coefficients, which are robust to the choice of the weighting matrix, in these two countries are as follows. The elasticity of substitution is bigger in the UK (1.79 for the EWMD and 2 for the OMD) than in France (1.73 for the EWMD and 1.86 for the OMD). The flexibility parameter ρ is always lower in France than in the UK with the estimates of 0.77 versus 0.85 for the EWMD method and 0.86 versus 0.98 for the OMD method. This confirms the fact that wages are less flexible in France than in the UK. It also suggests that the labor market institutions in France made wages rigid at least to some extent, and that this rigidity affected the development of wages and labor force status proportions in the economy during the analyzed period. The negative effect of marital status on the female labor supply in France is much bigger in the magnitude than in the UK. The same holds for the positive marital status effect on the labor supply of men, although the difference is smaller. The effect of the presence of children on female labor supply is much smaller in France than in the UK (-0.06 versus -0.38 for EWMD, and -0.08 versus -0.33 for OMD). This result may partly reflect the fact that there is better (less costly) child-care availability in France than in the UK. The effect of children on labor supply of men is not significant in France when estimated by EWMD, and it is negative with a similar magnitudes for the OMD and in the UK, irrespective of the method used. The total sensitivity of the labor supply to the true exogenous supply

work).

shifters is slightly lower in France than in the UK.[57]

The structural results for the US suggest that there is a relatively high elasticity of substitution (1.79 for EWMD and 1.96 for OMD) similar to the UK. The wage elasticity of labor supply (0.11 and 0.16) is closer to the one in France. Similar to the UK, the costly child-care in the US may be the cause of the relatively high effect of children on the female labor supply (-0.23 and -0.31). As for the wage flexibility, the two methods give contradictory results. While the EWMD method suggests rather flexible wages (0.84), a value similar to the UK and consistent with the expectations, the OMD method gives a surprisingly low estimate of 0.73, which is the lowest among the three countries. The OMD estimation also suggests an unusually high effect of the presence of children on the male labor supply. Because of these two anomalies, I focus on the EWMD estimation as the preferred results for the US. However, given the controversial findings for these two coefficients, the interpretation of the US results has to be taken with caution.

The EWMD results (in both Tables 4 and 5) partially support the trade-off hypothesis. The "effective" wage flexibility parameter is found to be the lowest in France (0.76-0.77), followed by the US (0.82-0.84) and the UK (0.85). As already discussed this is to some extent in line with the observed empirical facts. The labor market institutions in France, such as minimum wage and collective bargaining led to an increase in the real wages (both absolute and relative) of the low-skilled in spite of the continuing adverse exogenous demand developments against these groups. In accordance with the trade-off hypothesis, it was employment (that decreased among men) rather than wages, where the decline in the demand for the low-skilled was pronounced in France. However, as described in Section 4.2, the observed reduction in employment among the low-skilled men in France saw corresponding increases in inactivity rather than unemployment. As revealed on the simulations based on the reduced form estimates, this rise in inactivity in France was demand driven. This suggests that other factors might have caused these developments, including for example the early retirement policies aimed at reducing unemployment or a discouraged worker phenomenon.

The results also underscore the potential relevance of the extended trade-off hypothesis, as all three countries are found to have positive and significant wage elasticity of labor supply (with the US at a similar level as France and the UK substantially higher); it suggests that the high inactivity rates in the US and the UK may be a result of the low relative wages of their low-skilled.[58]

[57] As the RHS variables are the group fractions of the individuals that have the particular indicator (married or pre-school children present) equal to one, the sum of these coefficients can be roughly thought of as the overall sensitivity.

[58] The sensitivity of the labor supply to wages is found positive and significant in France as well, but there the slowly (less than in the other two countries) rising inactivity rates among the low-skilled cannot be attributed to the changes in wage, as both the absolute and the relative wages of the low-skilled have risen during the analyzed period.

6 Conclusion

This paper estimates a model of labor supply and labor demand for different skill groups in France, the UK and the US between the years 1990 and 2002. The aim of this paper was three-fold: first, to analyze the effect of market forces (exogenous changes in the labor supply or labor demand) and wage rigidity on the developments in relative earnings and labor force status of the different skill groups in these three countries; second, to test the validity of the so-called trade-off hypothesis which states that high wage inequality in the US and the UK and high unemployment in countries of continental Europe such as France are the consequence of the same negative change in the demand for the low-skilled under different degree of wage rigidity; and third, to re-assess the relevance of the model estimated in Card et al. (1999) when extended and estimated in its complete form.
An extended version of the trade-off hypothesis has been proposed suggesting that, if labor force participation is not perfectly wage inelastic, wage inequality is likely to be accompanied by high inactivity rates as well. The trade-off the policy-makers face is then one between wage inequality as well as high inactivity on one hand and high unemployment on the other.

Predictions of the trade-off hypothesis are only weakly supported by the reduced form results. While the responsiveness of the wage to the demand shifter does not significantly differ across the three countries, the coefficient of the demand shifter in the employment equation is significantly higher in France than in the other two countries.

The simulations based on the estimated model suggest that demand as well as supply changes were in effect in all three countries during the 1990s. The three countries saw the same overall trend in the demand and the supply structures. The distribution of the population across the different education groups shifted from the low-educated towards the high-educated, thus increasing the supply of the high-skilled and reducing the supply of the low-skilled. The impact of the supply shifts was counteracted by the impact of changes at the demand side that were going in the opposite direction, as the exogenous forces further shifted the demand away from the low educated groups and towards the more educated. The earnings and labor force status development for the respective education groups in the three countries was determined by the relative strength of the two factors of changes in the supply and changes in the demand.

The simulated counterfactual series suggest that the exogenous shifts in the demand dominated for the employment rates across the education groups in France, while in the US it was supply shifts that had more impact. The mutually opposite effects of the supply and the demand shifts in the UK were of similar magnitudes, with the supply effects dominating for the least and the most educated. Inactivity rates were driven by changes in the demand in France and the UK, while supply changes played the more substantial role in the US. In accord with the reduced form coefficient estimates, the simulation results are partially consistent with both the standard trade-off hypothesis and its extended version.

Structural results provide further evidence in favor of the hypothesis. The preferred specification shows that the degree of wage flexibility is (in accordance with the prior expectations) significantly lower in France than in the two other countries. These findings also implies that institutions which increase wage rigidity played role in the earnings and labor force status developments in France during the period under analysis.

We find positive and significant wage elasticity of labor force participation in all three countries which suggests that the high inactivity rates may be a consequence of the low relative wages of the low-skilled, as proposed by the extended trade-off hypothesis.

All structural parameters have reasonable values within expected ranges and the goodness-of-fit statistics imply that the theoretical model describes the data quite well. The full results seem to provide more support for the empirical relevance of the model than the partial findings presented in Card et al. (1999) do. However, the magnitudes of the structural coefficients, and in particular their cross-country comparisons, seem to be rather sensitive to whether identical or optimal weighting matrix is employed in the minimum distance method. A separate inquiry would be required in order to determine which of the two methods should be preferred.

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Data Sources

- Current Population Survey, March CPS Supplement, Bureau of Census and Bureau of Labor Statistics, USA
- *Labor Force Survey*, the UK Data Archive
- *Enquête Emploi*, INSEE and LASMAS-IdL, France
- OECD Statistical Database, Statistics Portal, Labor Force Statistics Data and Indicators, http://www.oecd.org/
- STAN Indicators Database (2004), Source OECD, Paris
- Institut national de la statistique et des études économiques, Paris, France, http://www.insee.fr/
- National Statistics, UK, http://www.statistics.gov.uk/statbase/
- Bureau of Economic Analysis, USA, http://www.bea.gov/

Appendix

A Data Description and Sources

The three national labor force surveys used in the present analysis are *Enquête Emploi* (1990-2002) for France, *Labor Force Survey* (1993-2002) for the UK, and the *March CPS* (1990-2001) for the US. The period is limited either by absence of the information on the key variables in the labor force surveys (no wage information in earlier years requires the UK analysis to start only in 1993), or the absence of the industry-based data for the construction of the demand shifter (the industry-based indicators are not yet available for some countries after 2001 which is why the analysis of the US data ends one year earlier than for the other two countries).

All three datasets have a character of a short rotational panel, so that a fraction of the individuals overlaps in two consecutive years. As the present analysis utilizes a panel of grouped data with the groups based on age, the panel nature of the individual data is ignored and all the individuals are treated as newly randomly sampled in each year. The sample employed in the analysis is the non-institutionalized population between the ages of 25 and 54, excluding students, conscripts and individuals in Armed Forces. The analysis makes use of all these individuals in the datasets regardless whether they come form the same household or not. In this sense, intra-household correlations are ignored. However, for the construction of the group-level information for the skill-groups, treating all the individuals as independent seems to be rather innocuous, and substantially increases the sample size.

The use of the UK Labor Force Survey requires more detailed description. It is a quarterly survey that follows households for 5 consecutive quarters. In each quarter, one fifth of the households leave the sample and is replaced by a new wave. Although the questions asked in each quarter are almost the same, information about earnings is only available in the quarter when the households are in the survey for the last time (i.e. only for the outgoing wave).[59] The present analysis therefore uses the outgoing households in each quarter over a particular year to constructs a new dataset, which is than used to construct the group-level information for that year. In this sense, the UK grouped data is not directly comparable with the data from the other two countries which are more or less a point in time estimates (both surveys are conducted in Spring), whereas it is four points in time in different quarters of the year in the UK. This should be irrelevant for wage information which does not show much variation over the year, but could affect the labor force survey statistics, as employment does show some seasonality over the year. For now, this problem is neglected in the analysis. However, as the data in the UK is constructed in the same way in all years, and this analysis uses the fixed effect estimation that is based on the year-to-year differences, the problem should not have an impact on the estimation results. On the other hand, the summary statistics presented in the figures may be affected by this method of the data construction. The sample size and the size of the skill groups is summarized in Table A.1.

[59] The information about earnings is asked also in the second interview starting from 1997.

Table A.1: The Sample and Skill-Group Size Statistics

country	years	individual obs (all years)	no. of skill groups	group obs (all years)	smallest group size	largest group size
FR	1990-2002	934 719	72	936	150	2704
UK	1993-2002	458 107	60	600	168	2096
USA	1990-2001	864 323	72	864	176	3196

The skill groups are classified on the basis of gender, six age ranges (25-29, 30-34, 35-39, 40-44, 45-49 and 50-54), and six (five in the UK) education attainment categories, leading to 72 groups in total for France and the US, and 60 for the UK.

Education is classified to best fit the country-specific characteristics of the education system, as well as to produce reasonably large group-sizes over the entire period. In the UK the classification is as follows: 1 = "CSE below grade 1 or equivalent" (less than O-levels), 2 = "GCSE A-C or equivalent" (less than A-levels), 3 = "A level or equivalent", 4 = "higher education, below degree", 5 = "degree or higher". In France it is: 1 = "CEP or less" (primary), 2 = "BEPC" (junior high school), 3 = "CAP, BEP" (vocational or technical school) , 4 = "Baccalauréat" (academic high school), 5 = "undergraduate degree", 6 = "graduate degree". In the US, it is: 1 = "8th grade or below", 2 = "up to 12th grade, no diploma", 3 = "high-school graduate or equivalent", 4 = "some college but no degree, Associate's degree in college", 5 = "Bachelor's Degree", 6 = "Master's Degree and above".

The employment and the labor force participation rates are defined in the standard way: Employed individuals include the employed and the self-employed, as well as the unpaid family workers, and labor force participants are individuals who are either employed or unemployed (according to the ILO definition of unemployment).

The key measure the present analysis uses for earnings is the real hourly wage. In France, the hourly wage was constructed using the reported monthly wages from the previous month divided by 4.33 times the reported usual hours of work. In the UK, the hourly wage was already present in the dataset, constructed by the data providers using the reported current weekly wages and usual hours of work. In the US, hourly wage was constructed from the annual wage from the previous year, using the reported weeks worked in the previous year multiplied by the usual weekly hours of work. The reported hours of work per week were first trimmed (separately by gender and year) at the 1st and 99th percentile to avoid the outliers and top coded values, before used to construct the hourly wage. The resulting hourly wages were trimmed at the 5th and 95th percentile (separately by year and within each skill group) for the same reason.

The consumption deflators for the period come from the official statistical sites of the three countries: Personal Consumption Expenditure Deflator from the Bureau of Economic Analysis for the US, IPC (Indice des prix à la consommation) from INSEE

(French Statistical National Institute) for France, and CPI index (all items) from National Statistics in the UK. All three indices are normalized to have a base in 1995.

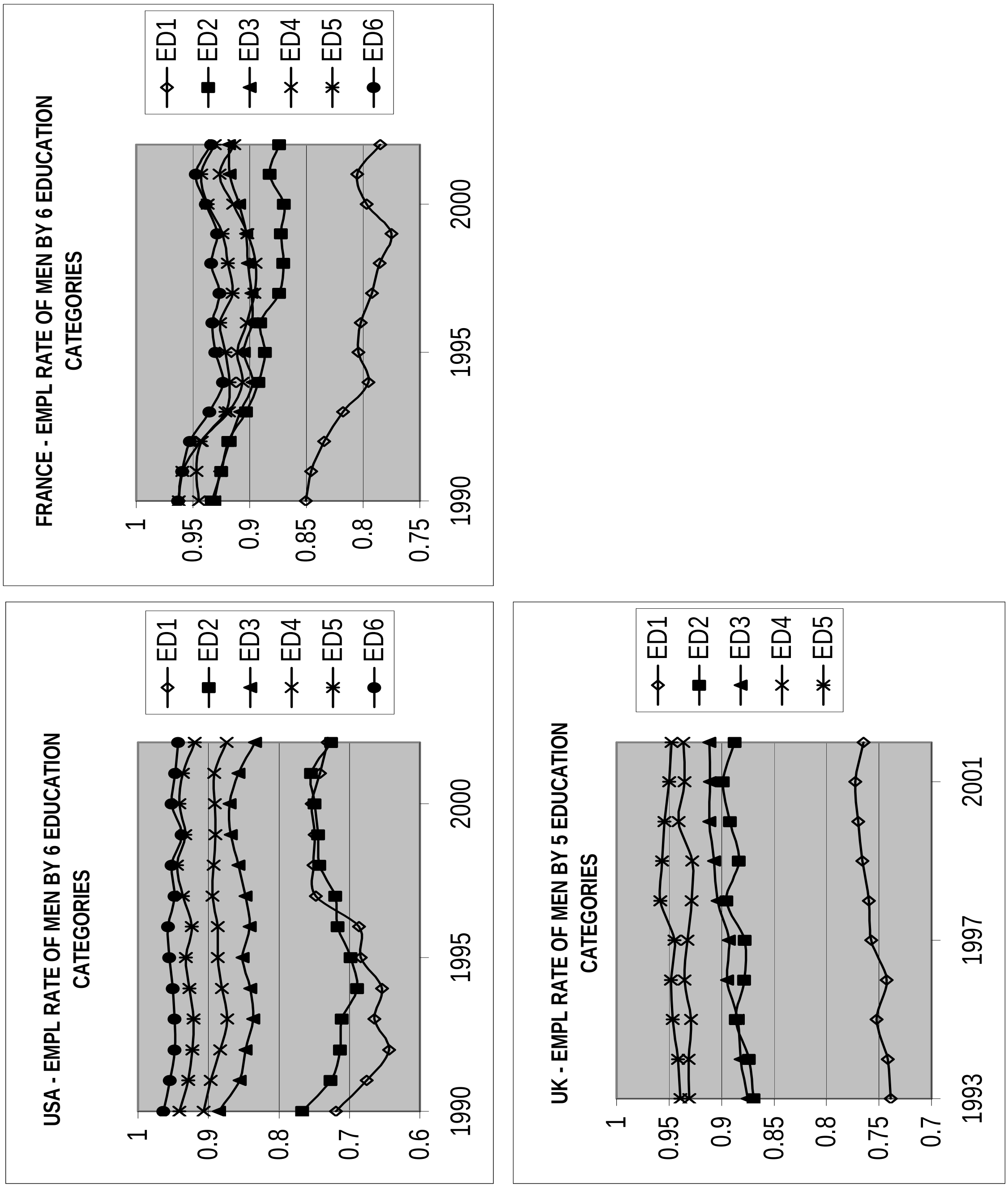
The value added shares of the individual industries used in the construction of the demand shifter come from the STAN Indicators database produced by OECD. There are 25 industry groups in the US, 24 in the UK, and 23 in France. The number of industries depends on the extent to which the national industry classifications in the individual level datasets correspond to the ISIC Rev.3 classification in the STAN database.

The exogenous supply side shifters are constructed as follows. Marital status describes the actual cohabitation (rather than the legal status), as it is assumed that cohabitation is likely to involve consumption and expenses sharing and income pooling, which are the key aspects affecting labor supply behavior. In the US, it is defined as "married with spouse present"[60], in the UK as "married with spouse present OR cohabitate" and in France as "cohabitate" (both married or not). The presence-of-children variable is defined as the presence of pre-school (less than 6 year old in the US and France, and less than 5 year old in the UK) children in the household. The information therefore does not necessarily describe individual's own children. It is not always possible to link children to their parents in the three datasets. Besides, this information may actually be preferable, as the presence children that require child-care can in principal affect labor supply behavior of any member of the household.

B Figures

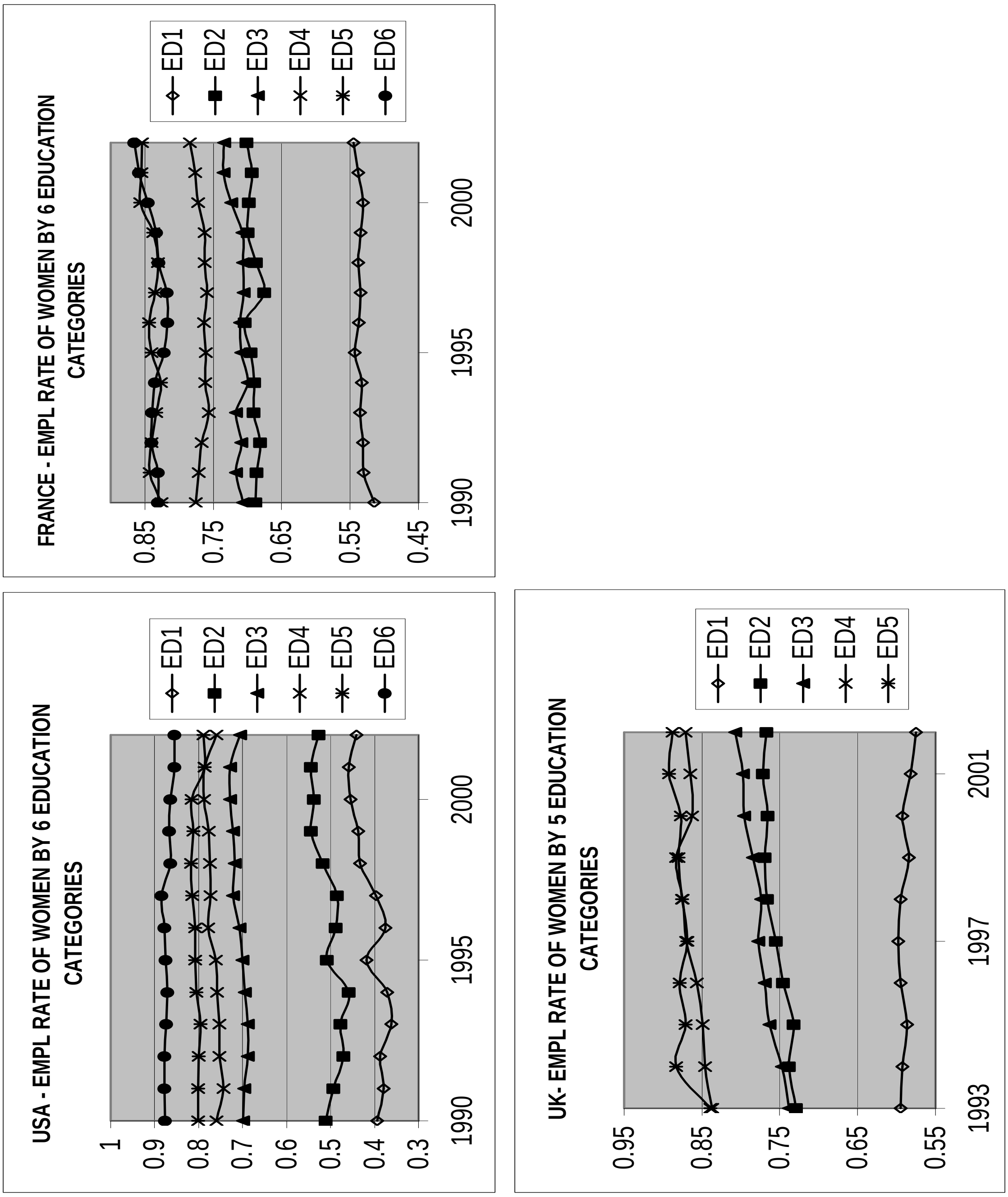
[60] Unfortunately, in the US dataset it is not possible to distinguish individuals that are not married but are living together.

Figure B.1: Employment Rate by the Educational Categories - Men



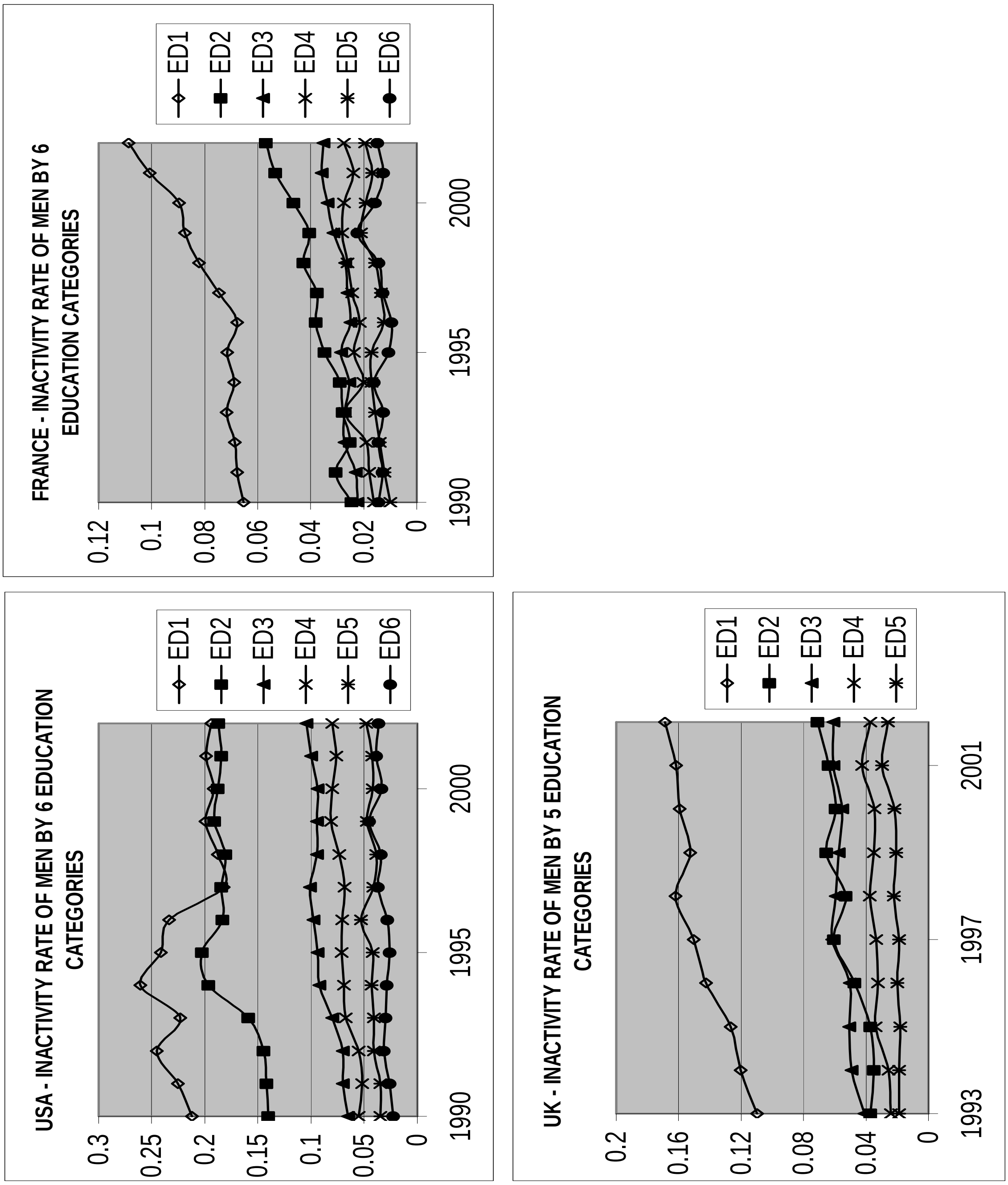
Out of school civilian prime age (24-54) population in France, the UK and the US. ED1 is the least educated group. Data is weighted by survey weights to reflect the population means.

Figure B.2: Employment Rate by the Educational Categories - Women



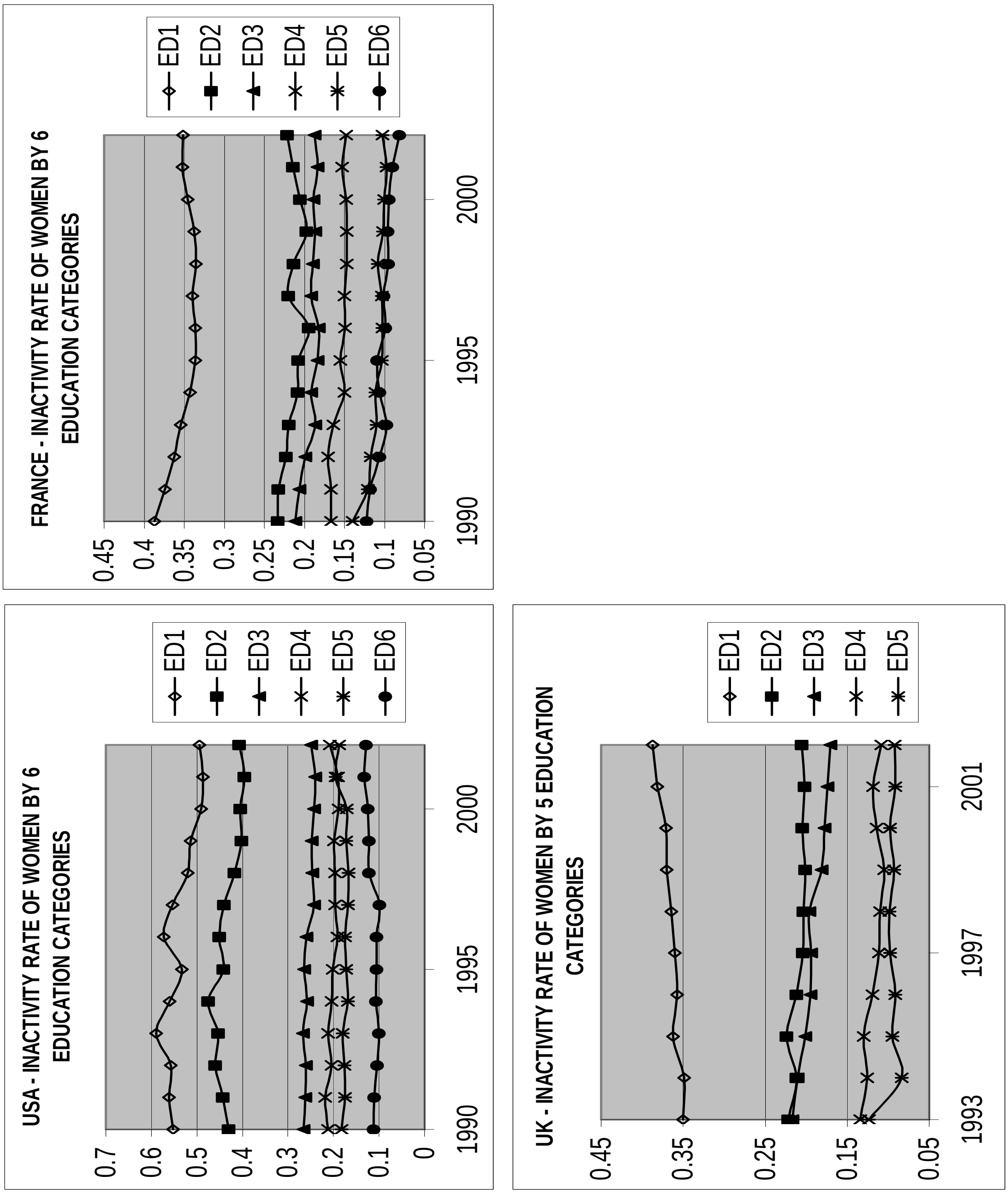
Out of school civilian prime age (24-54) population in France, the UK and the US. ED1 is the least educated group. Data is weighted by survey weights to reflect the population means.

Figure B.3: Inactivity Rate by the Educational Categories - Men



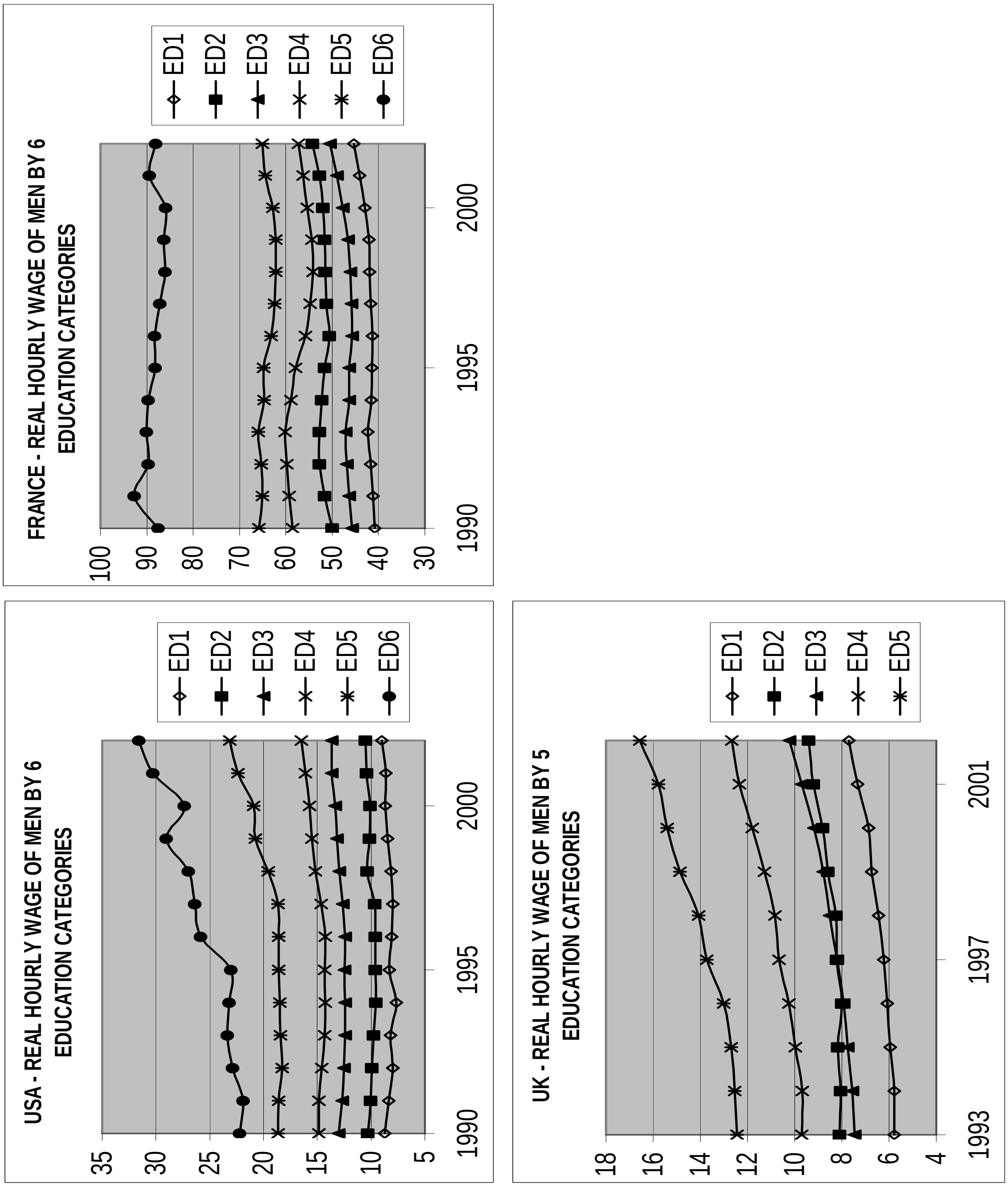
Out of school civilian prime age (24-54) population in France, the UK and the US. ED1 is the least educated group. Data is weighted by survey weights to reflect the population means.

Figure B.4: Inactivity Rate by the Educational Categories - Women



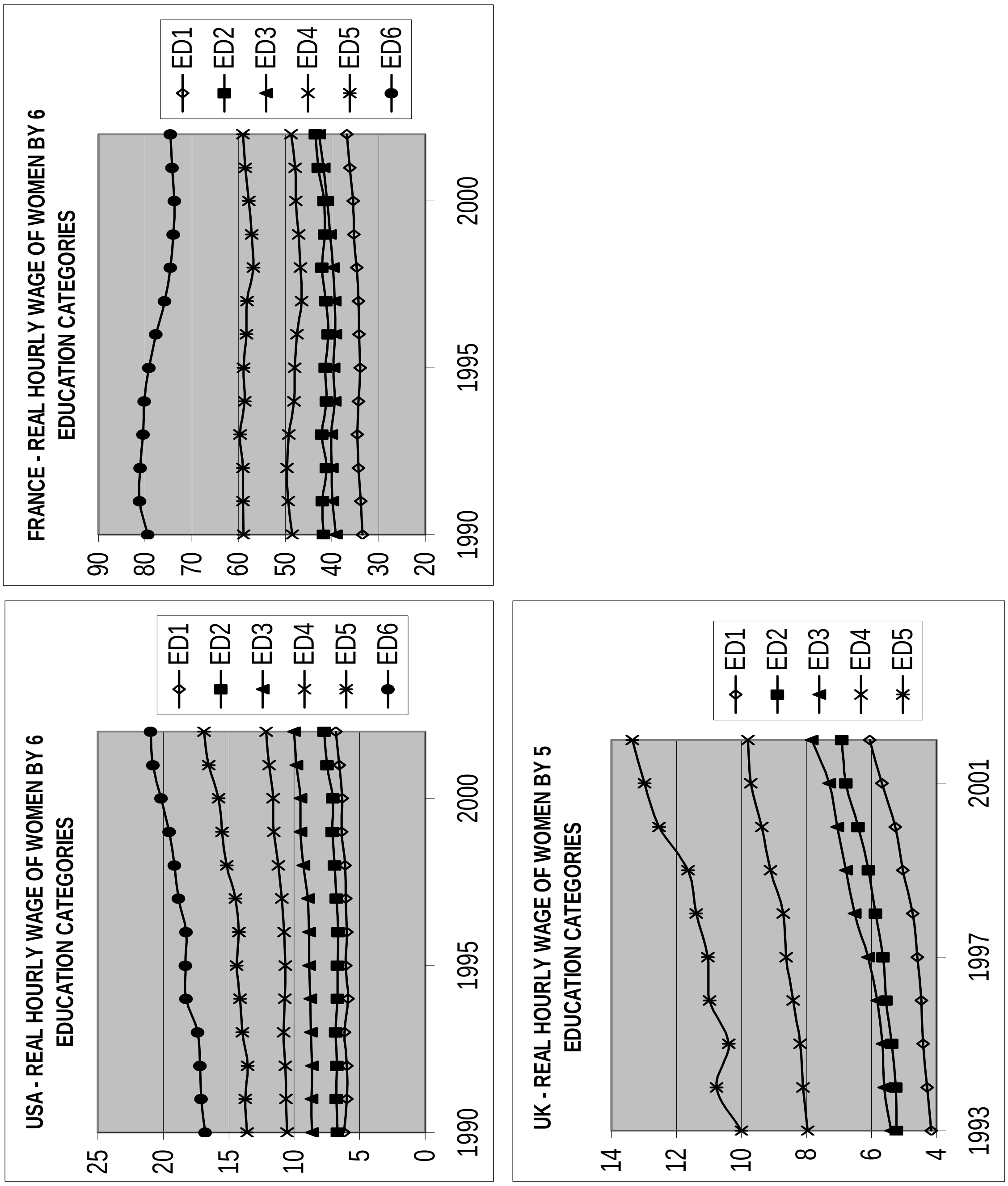
Out of school civilian prime age (24-54) population in France, the UK and the US. ED1 is the least educated group. Data is weighted by survey weights to reflect the population means.

Figure B.5: Real Hourly Wage Rate by the Educational Categories - Men



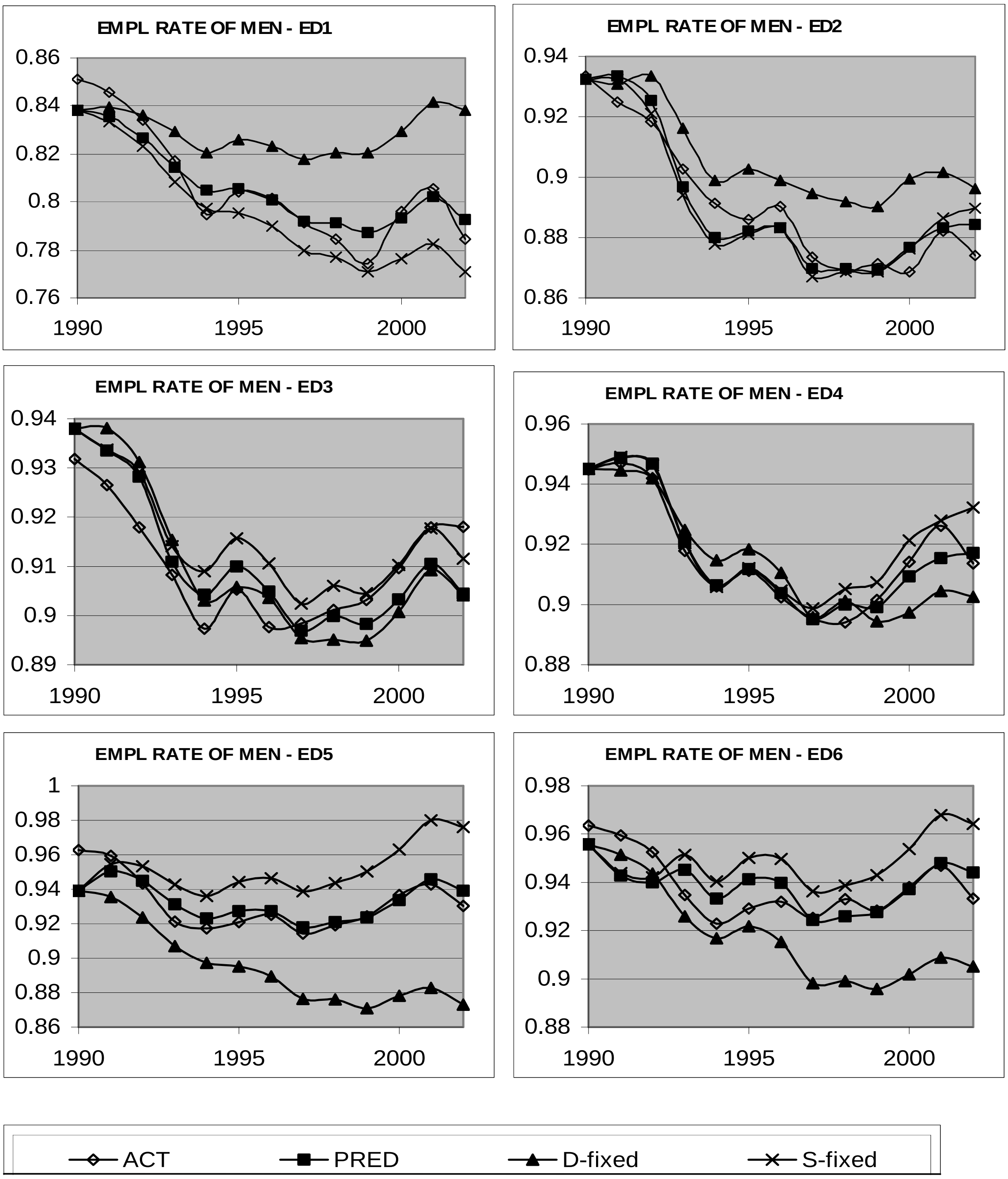
Out of school civilian prime age (24-54) population in France, the UK and the US. ED1 is the least educated group. Data is weighted by survey weights to reflect the population means.

Figure B.6: Real Hourly Wage Rate by the Educational Categories - Women



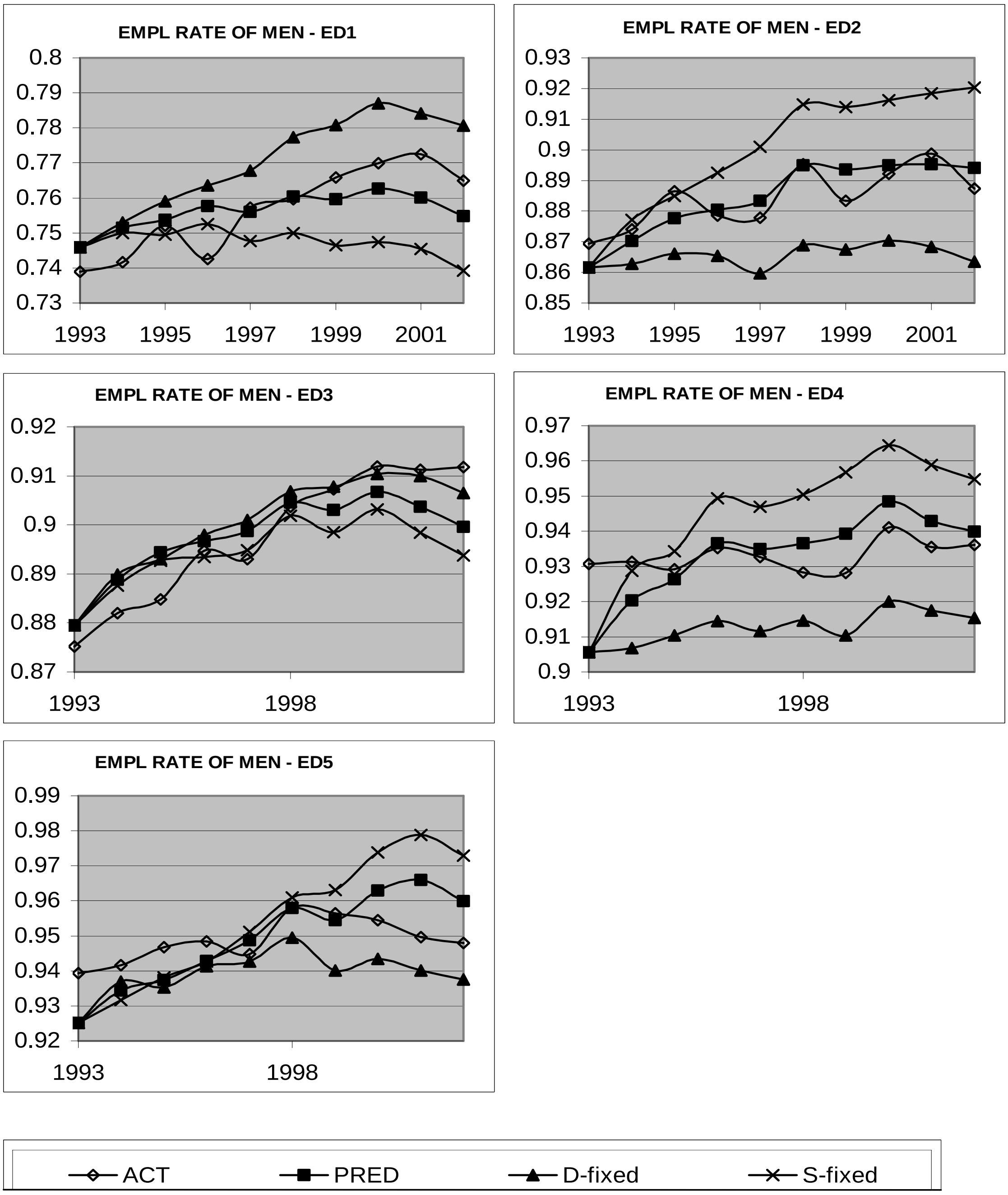
Out of school civilian prime age (24-54) population in France, the UK and the US. ED1 is the least educated group. Data is weighted by survey weights to reflect the population means.

Figure B.7: Employment Rate of Men by Education - France: Actual, Predicted and Simulated Series



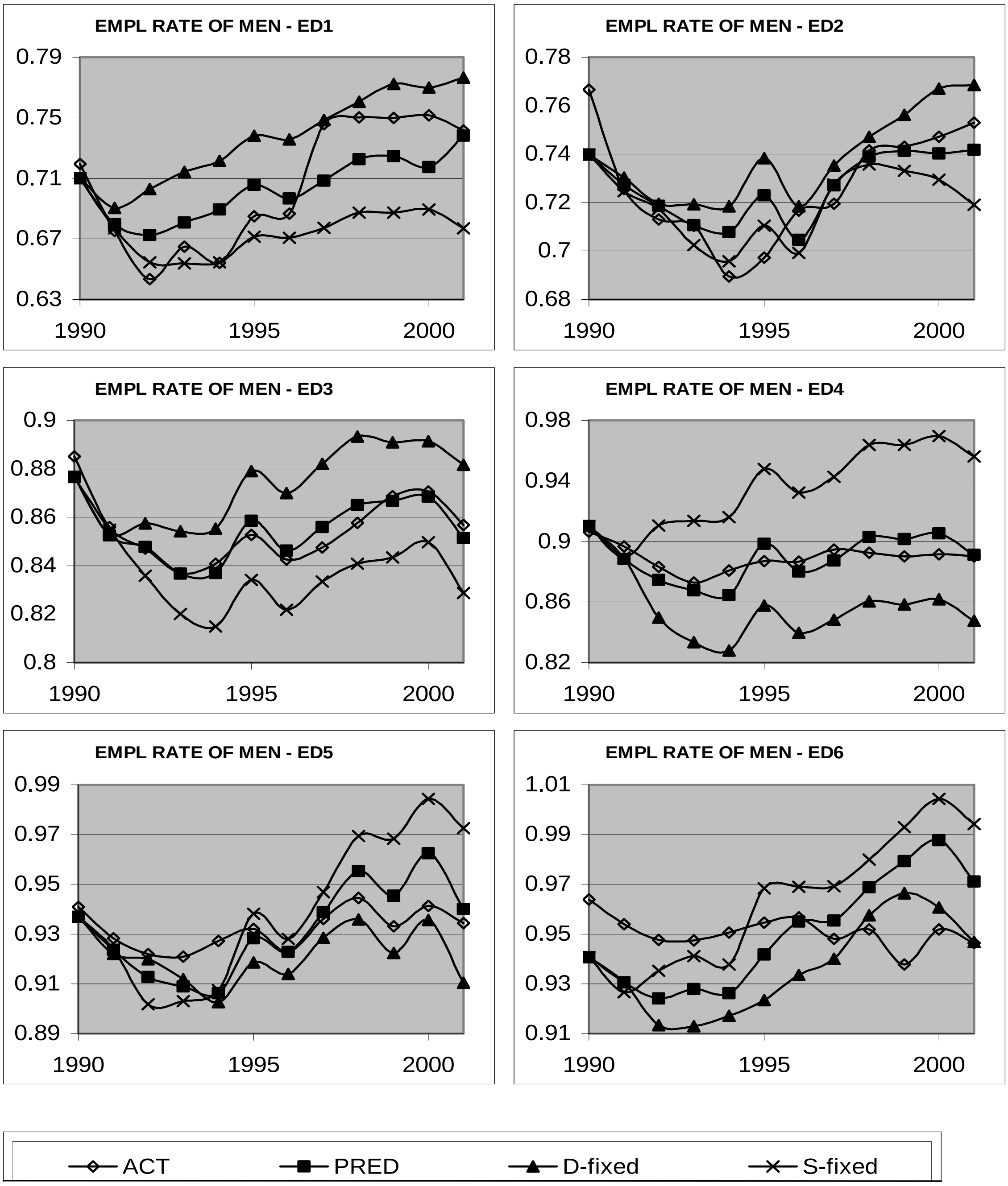
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.8: Employment Rate of Men by Education - the UK: Actual, Predicted and Simulated Series



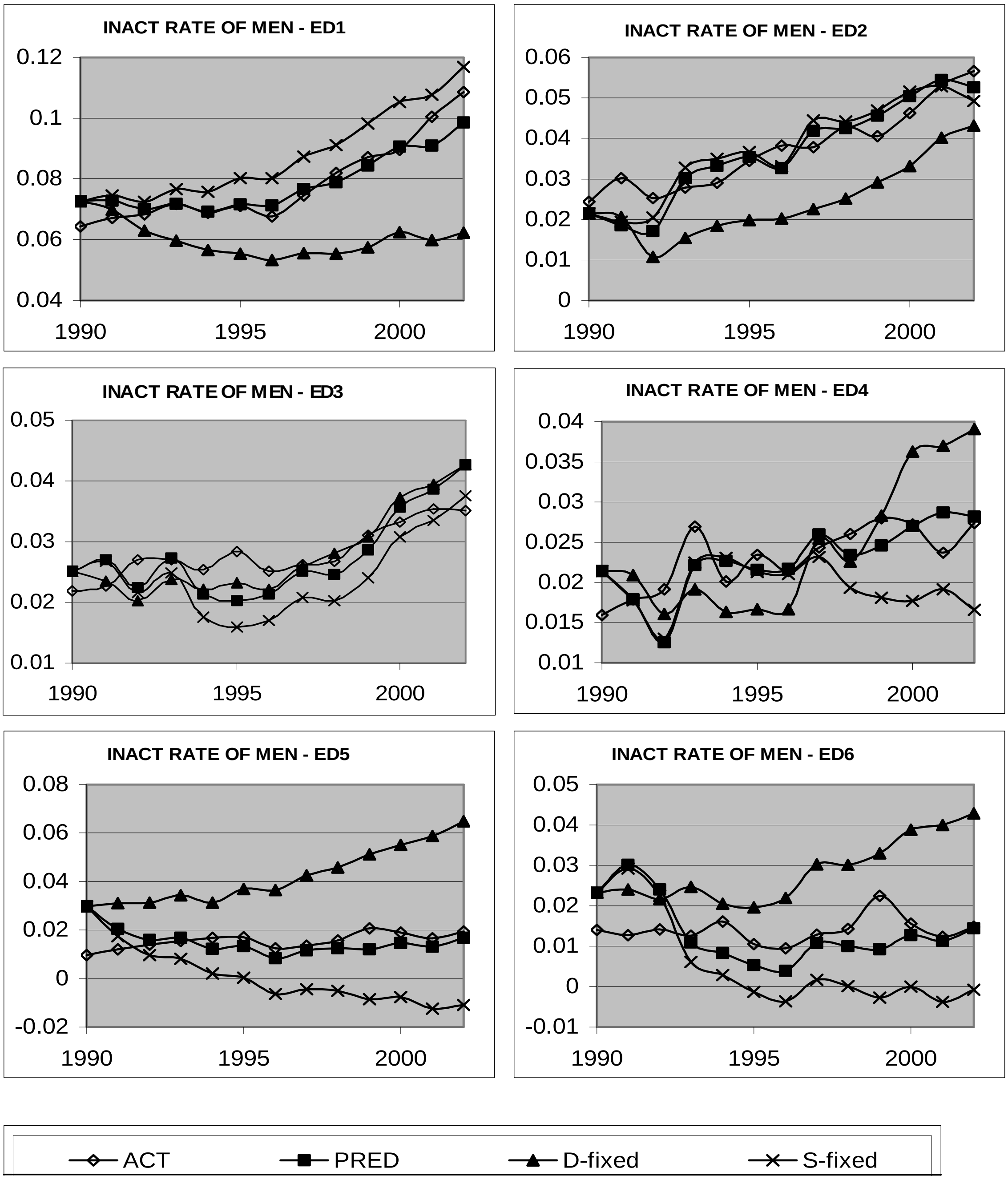
The five plots correspond to the five education groups, with ED1 being the least and ED5 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.9: Employment Rate of Men by Education - the US: Actual, Predicted and Simulated Series



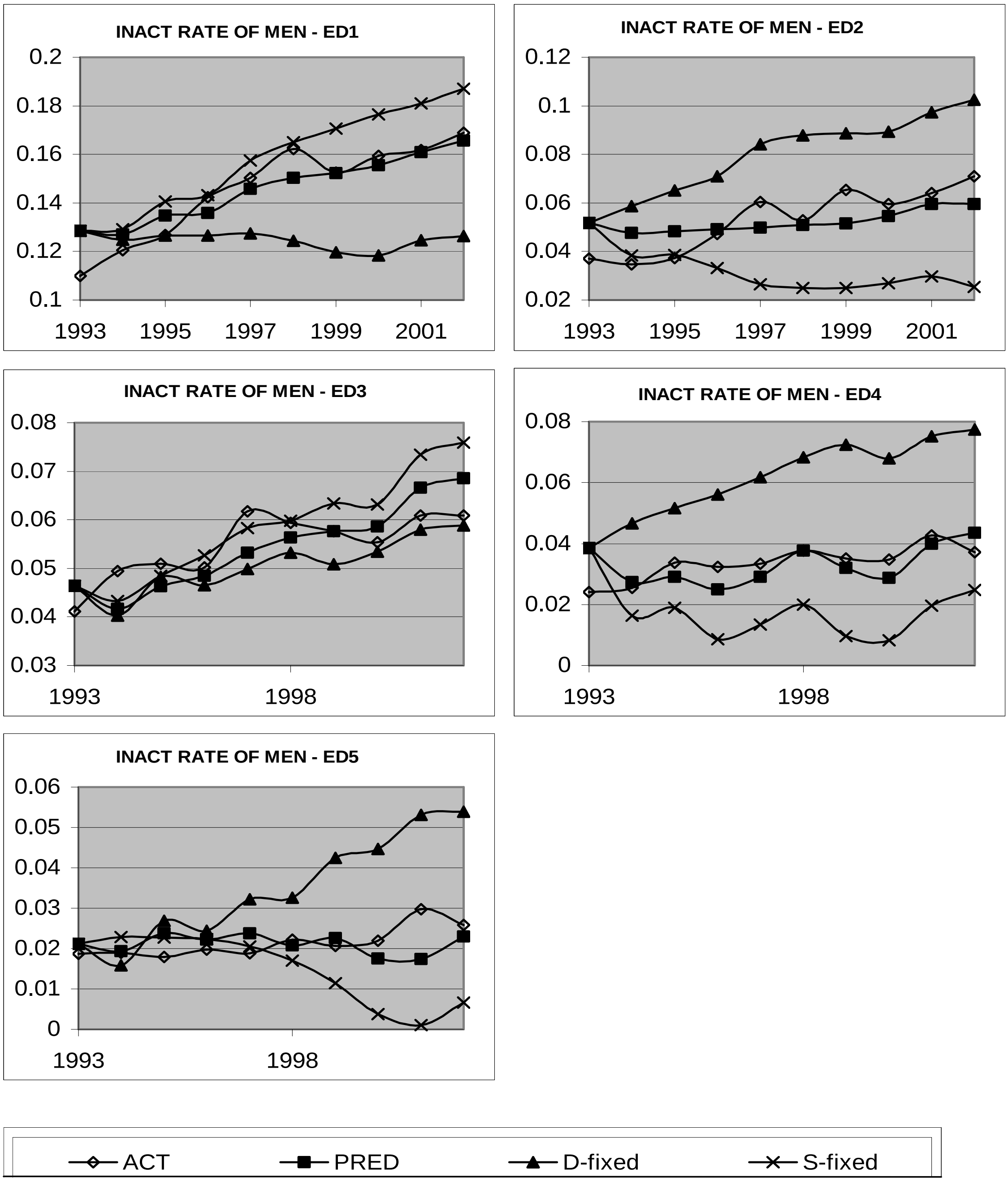
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.10: Inactivity Rate of Men by Education - France: Actual, Predicted and Simulated Series



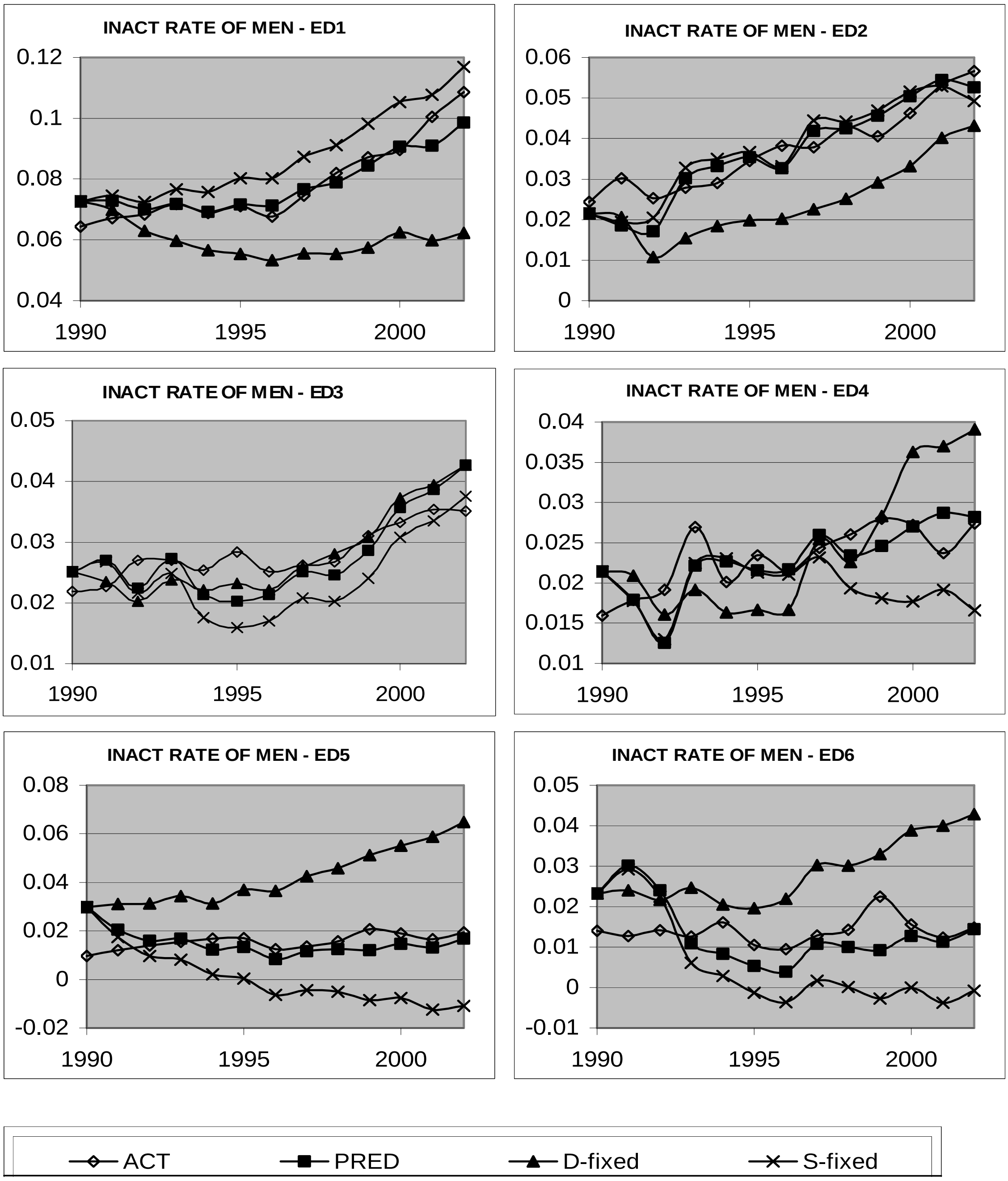
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The “D-fixed” and the “S-fixed” series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.11: Inactivity Rate of Men by Education - the UK: Actual, Predicted and Simulated Series



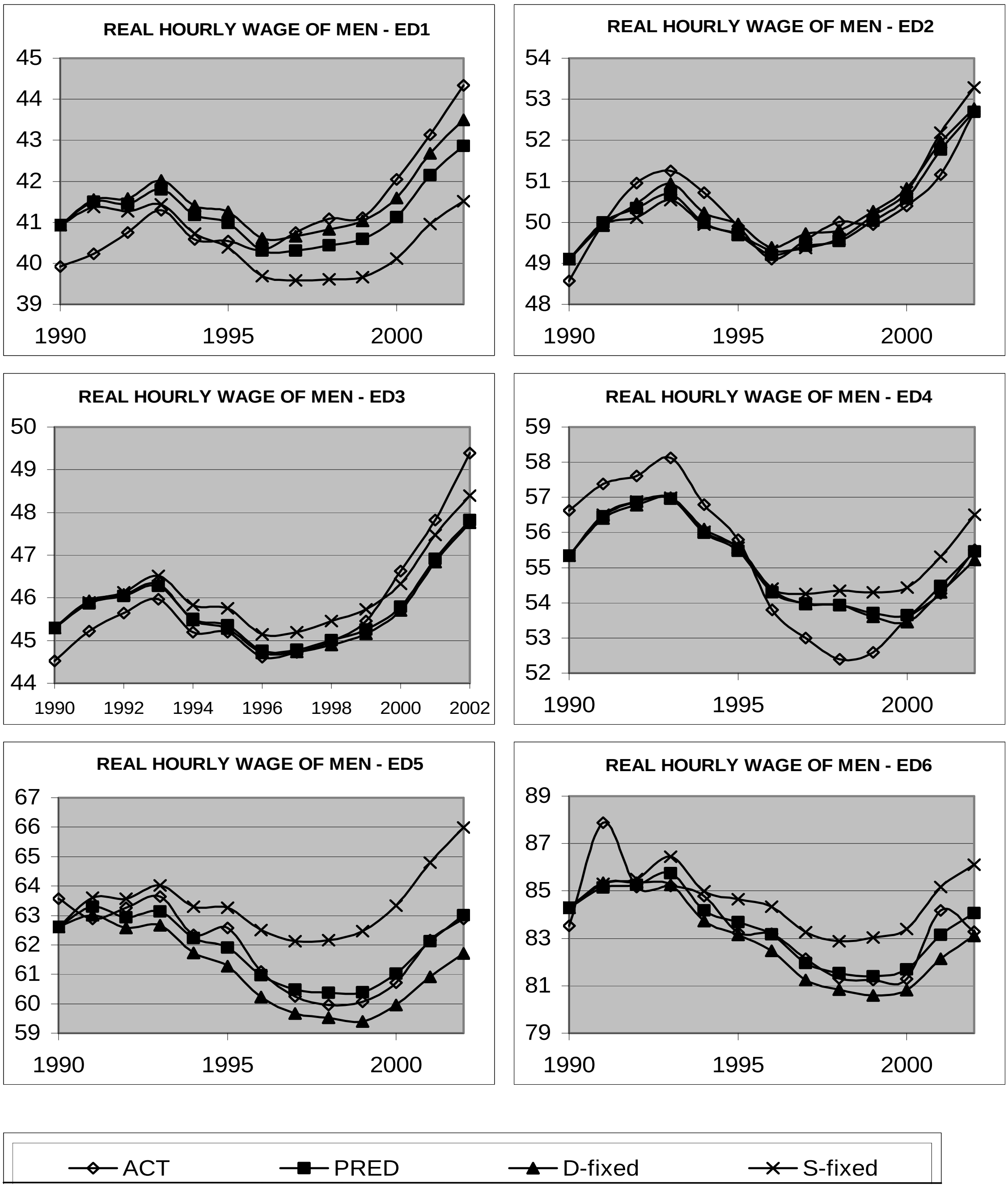
The five plots correspond to the five education groups, with ED1 being the least and ED5 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.12: Inactivity Rate of Men by Education - the US: Actual, Predicted and Simulated Series



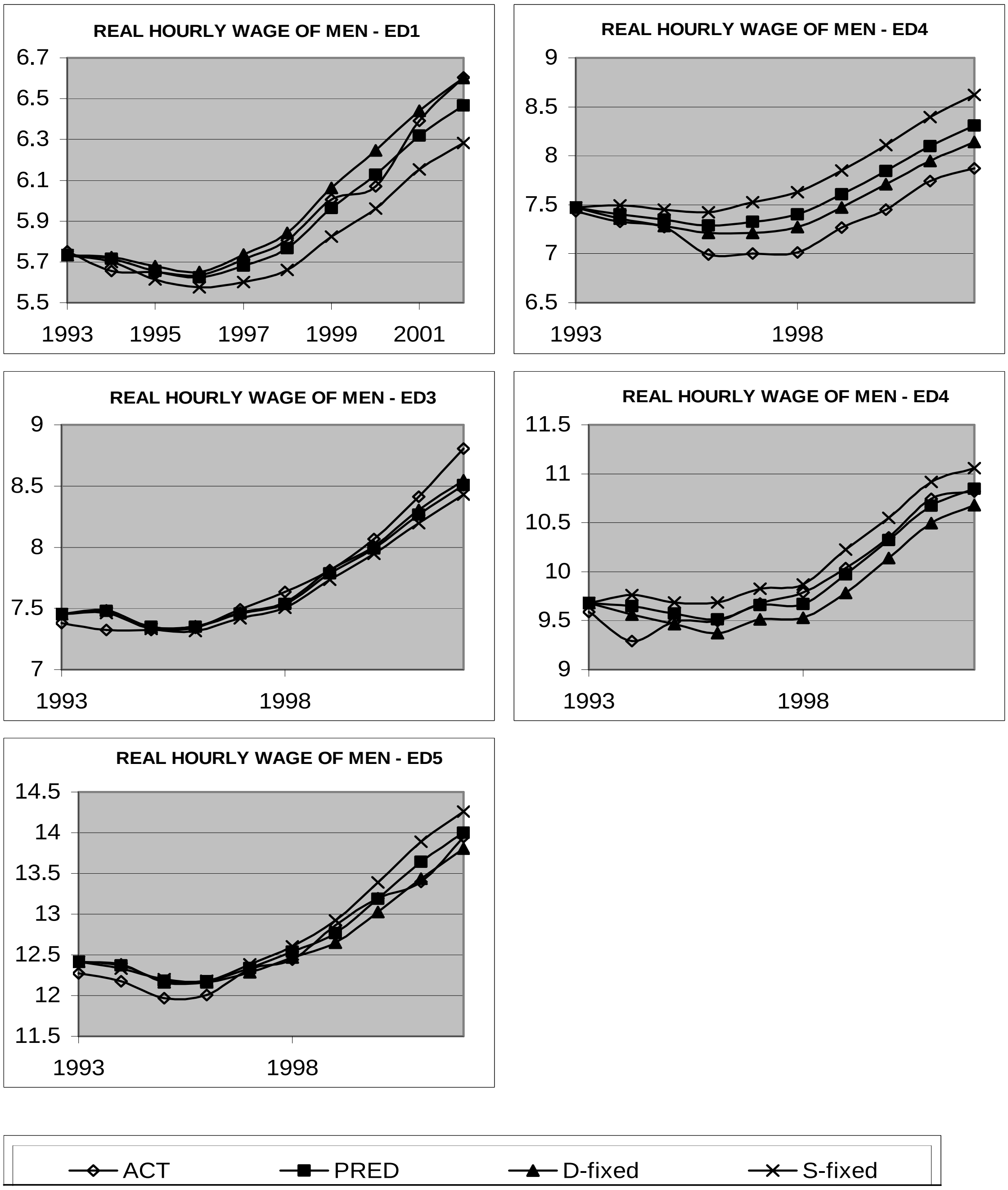
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.13: Real Hourly Wage of Men by Education - France: Actual, Predicted and Simulated Series



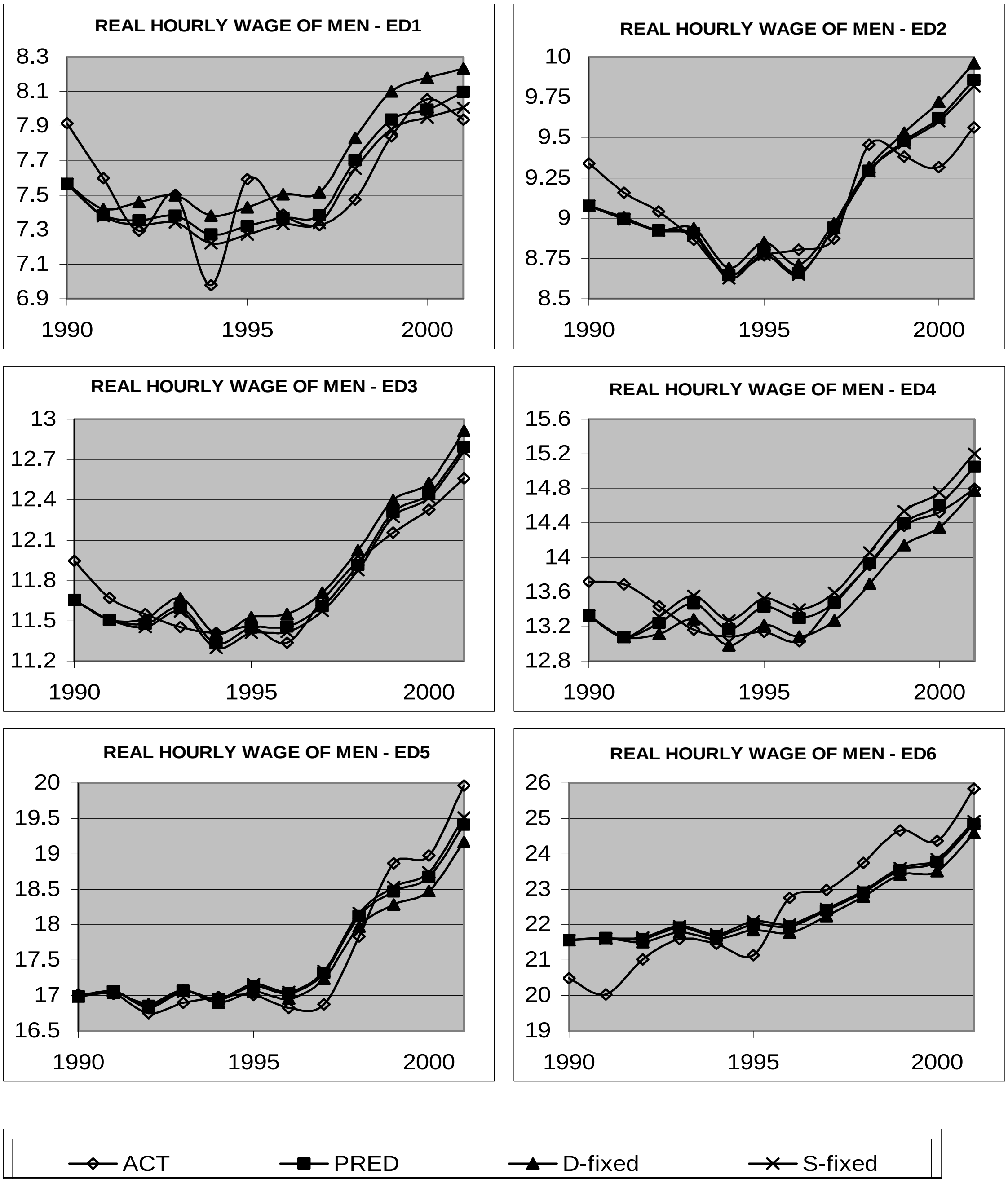
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.14: Real Hourly Wage of Men by Education - the UK: Actual, Predicted and Simulated Series



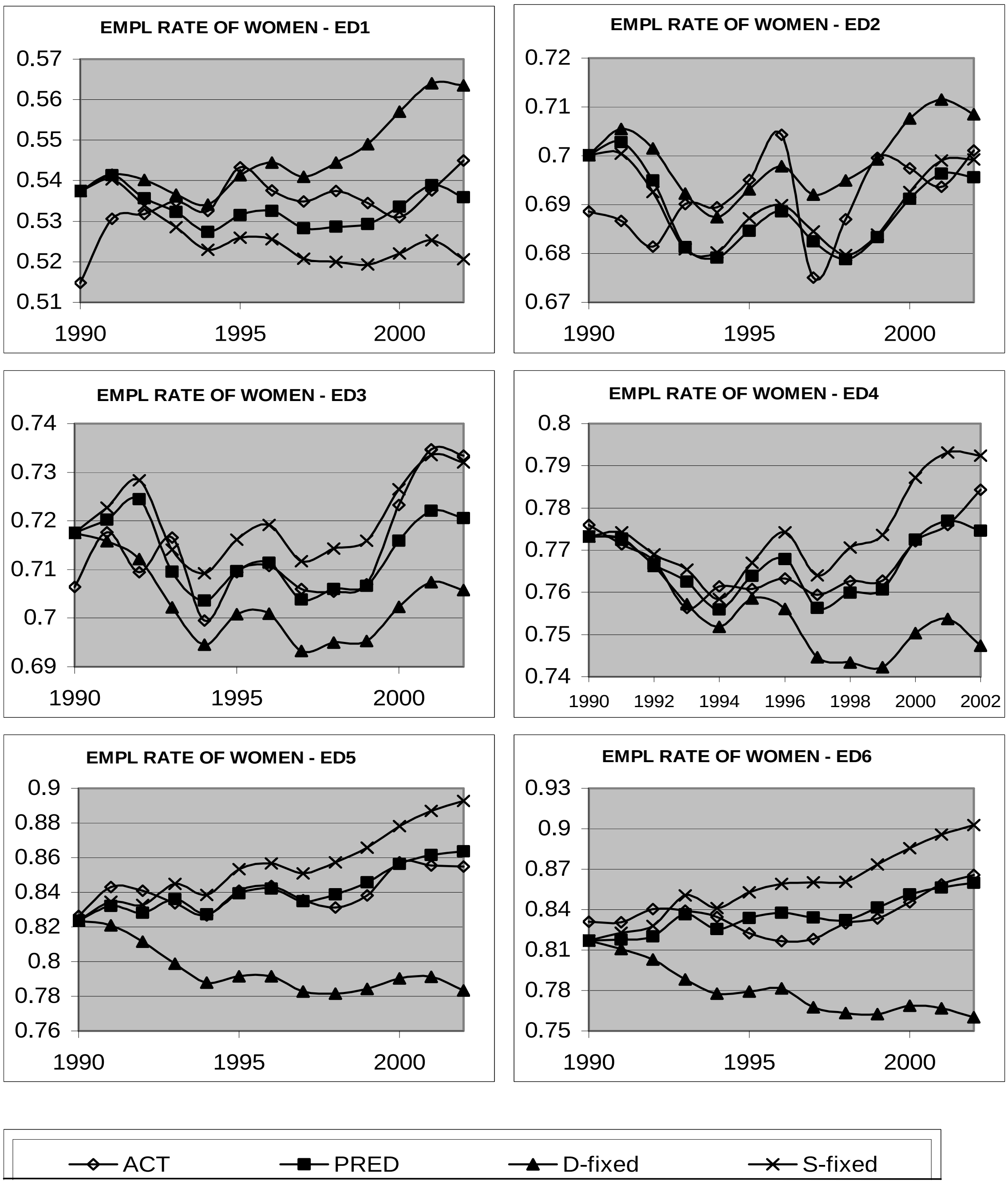
The five plots correspond to the five education groups, with ED1 being the least and ED5 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.15: Real Hourly Wage of Men by Education - the US: Actual, Predicted and Simulated Series



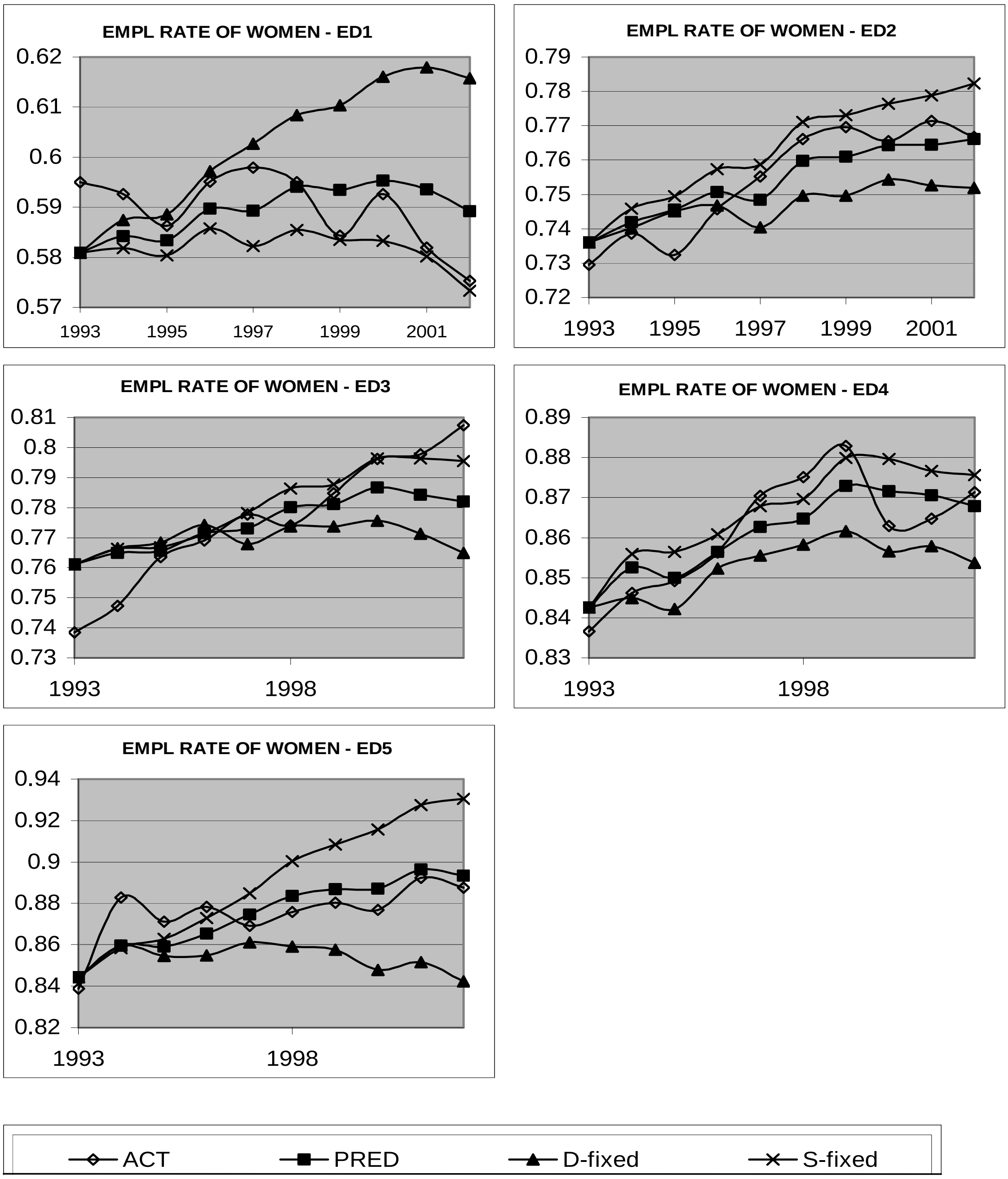
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.16: Employment Rate of Women by Education - France: Actual, Predicted and Simulated Series



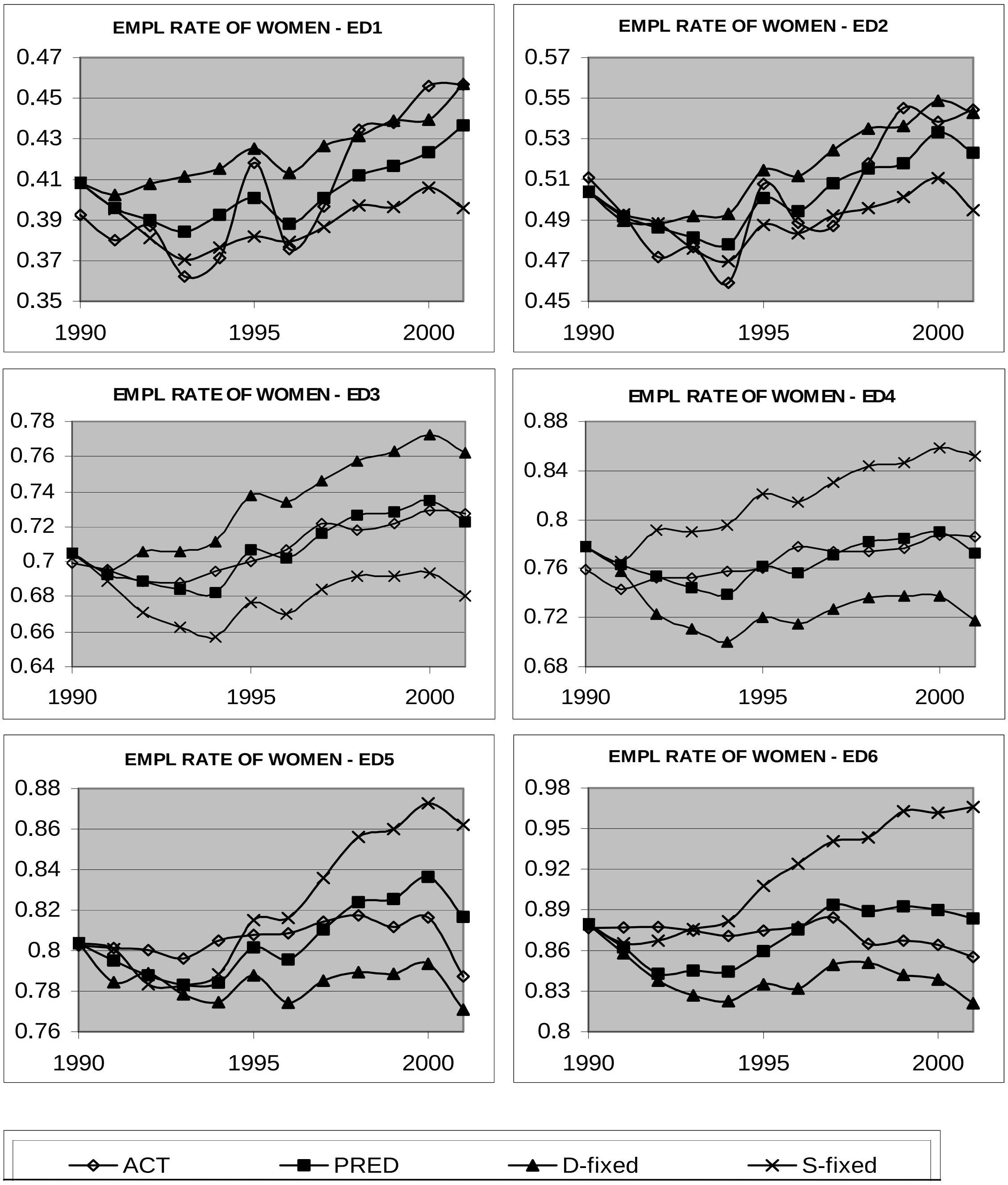
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The “D-fixed” and the “S-fixed” series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.17: Employment Rate of Women by Education - the UK: Actual, Predicted and Simulated Series



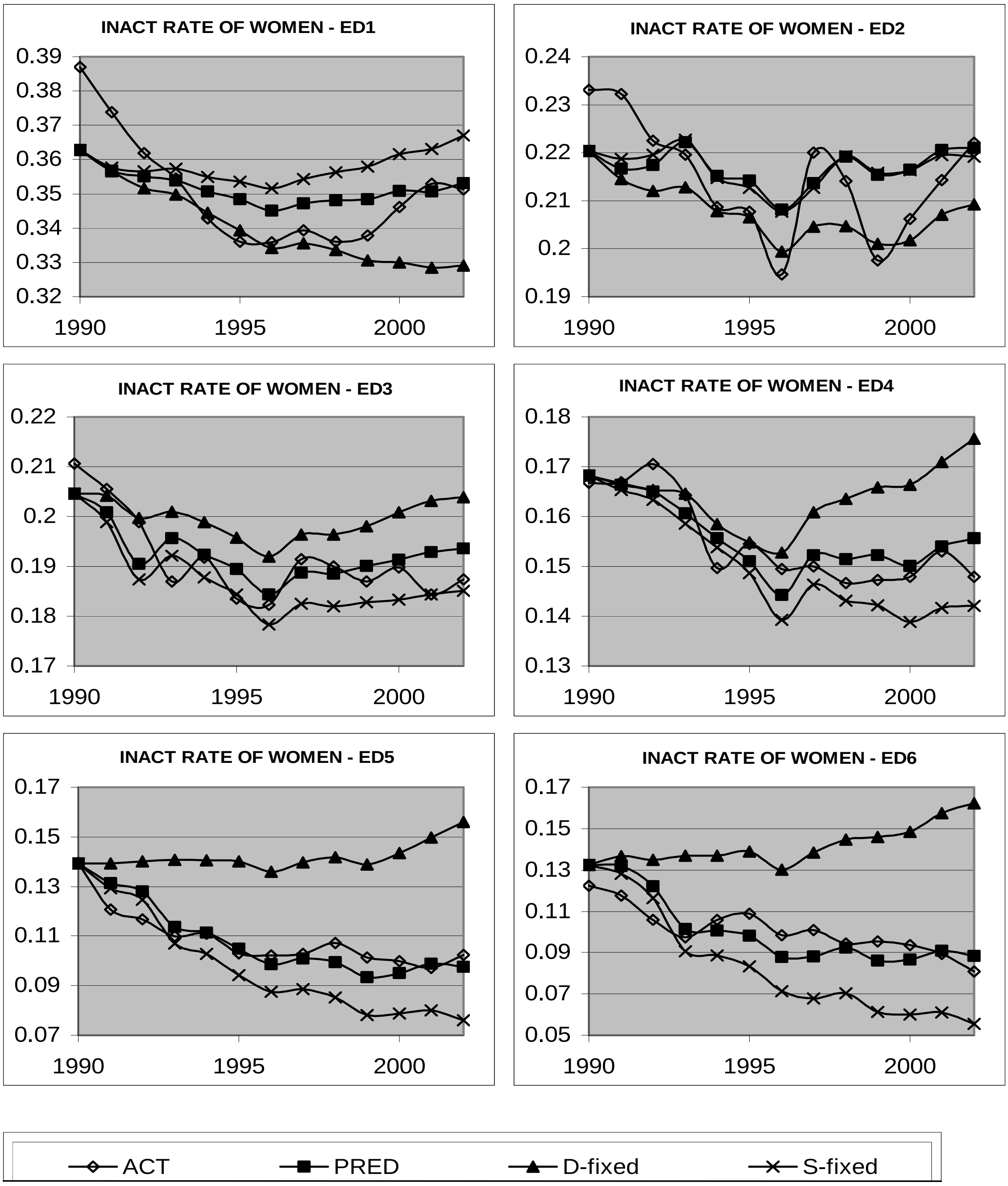
The five plots correspond to the five education groups, with ED1 being the least and ED5 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.18: Employment Rate of Women by Education - the US: Actual, Predicted and Simulated Series



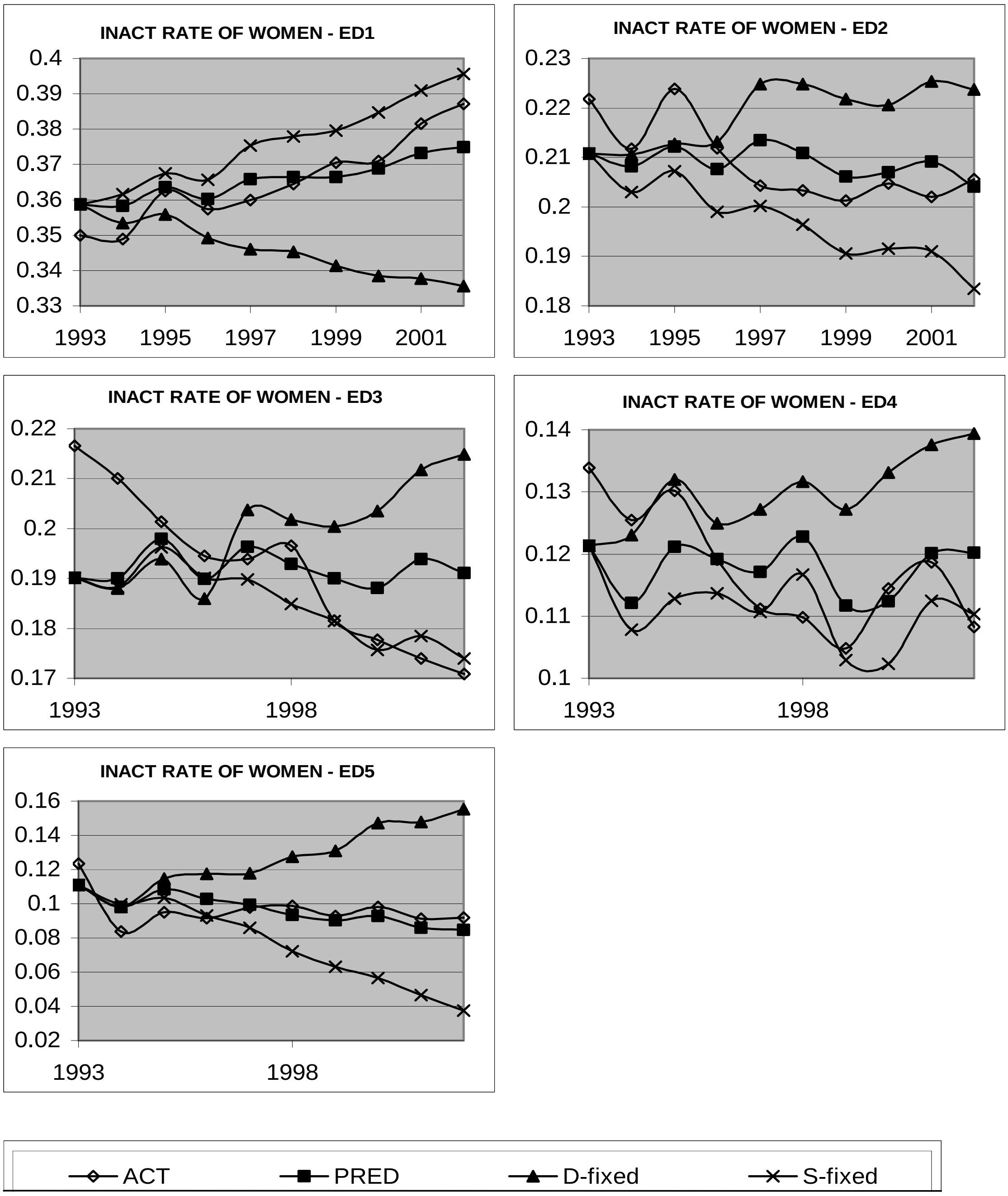
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.19: Inactivity Rate of Women by Education - France: Actual, Predicted and Simulated Series



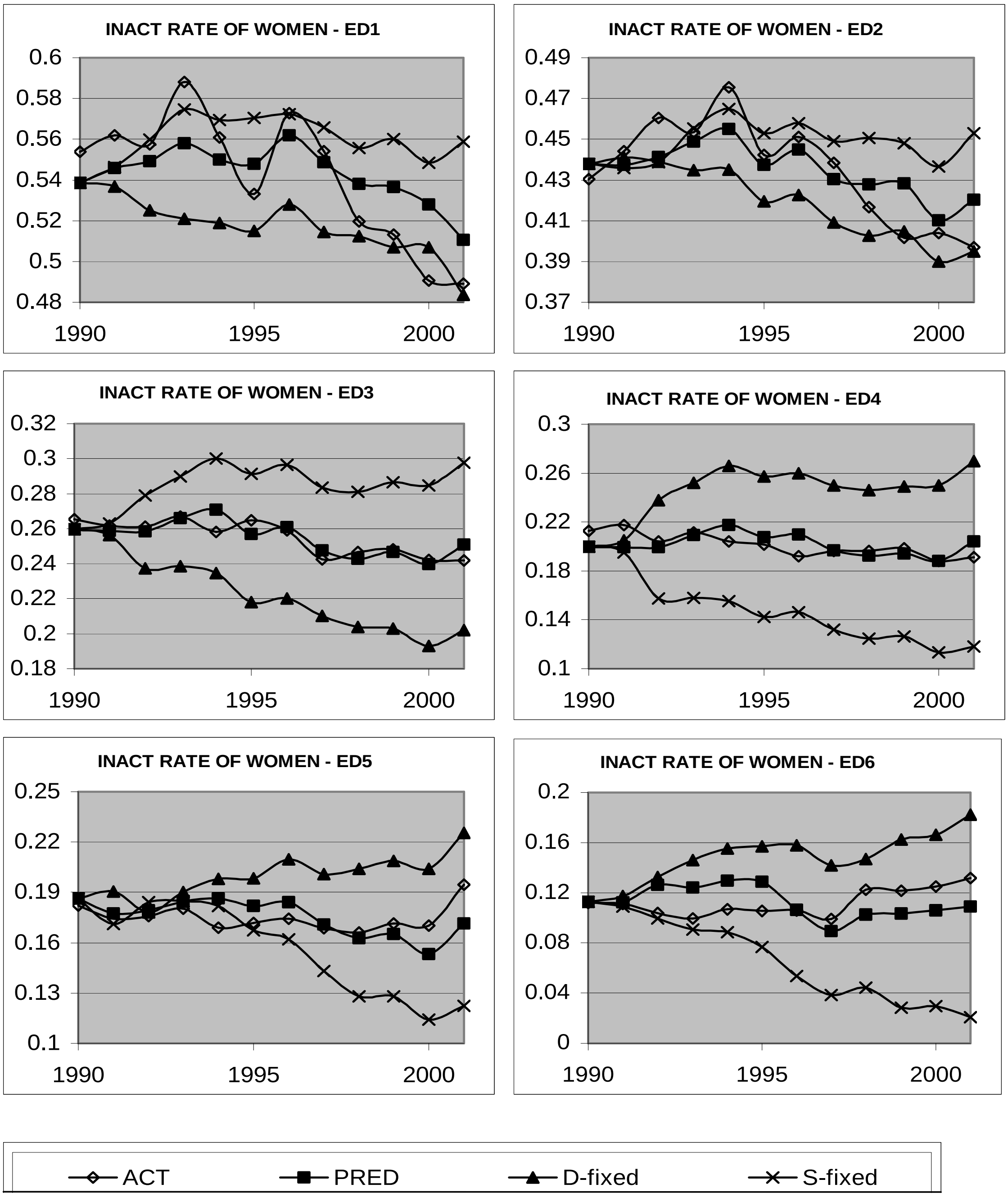
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.20: Inactivity Rate of Women by Education - the UK: Actual, Predicted and Simulated Series



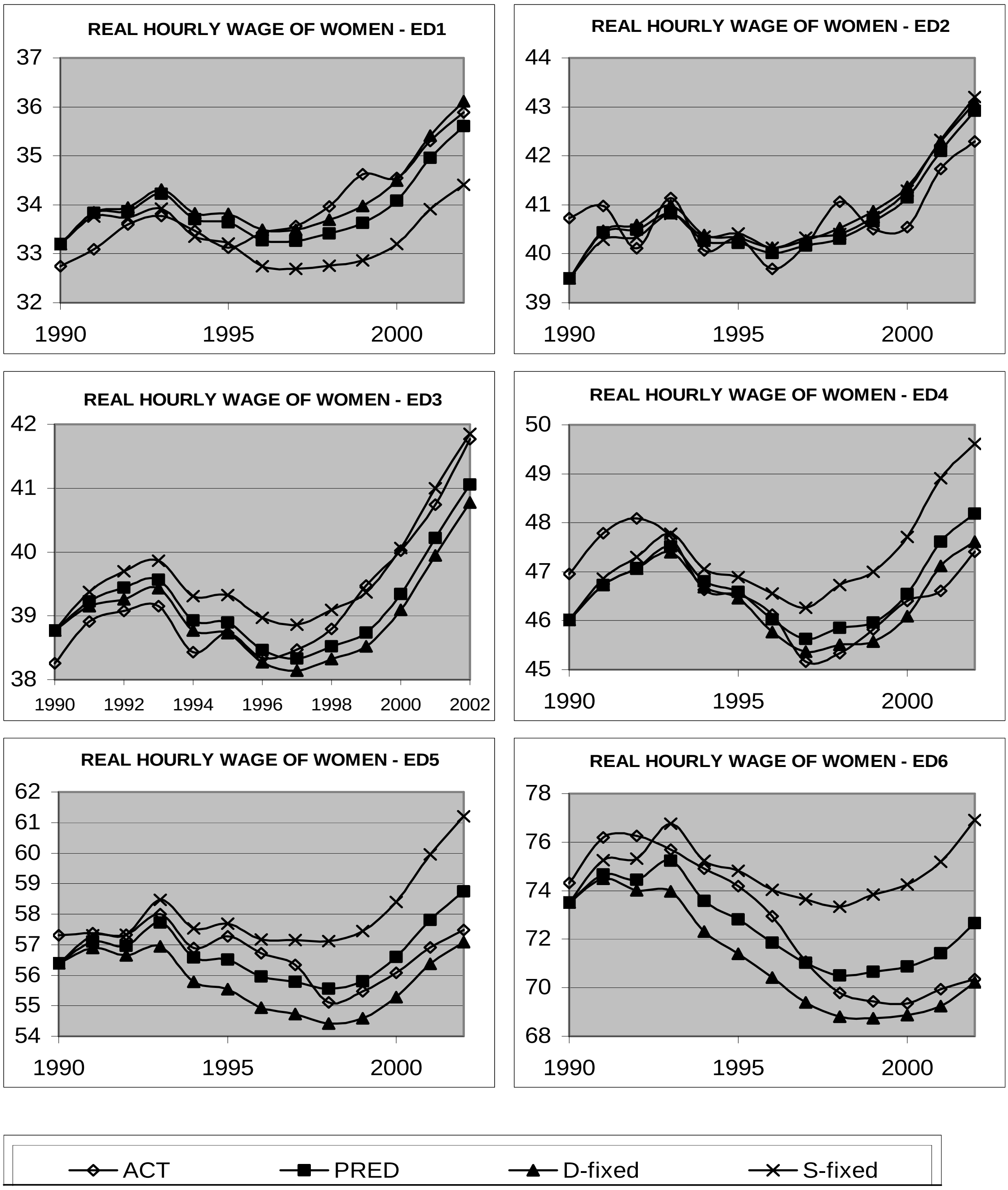
The five plots correspond to the five education groups, with ED1 being the least and ED5 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The “D-fixed” and the “S-fixed” series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.21: Inactivity Rate of Women by Education - the US: Actual, Predicted and Simulated Series



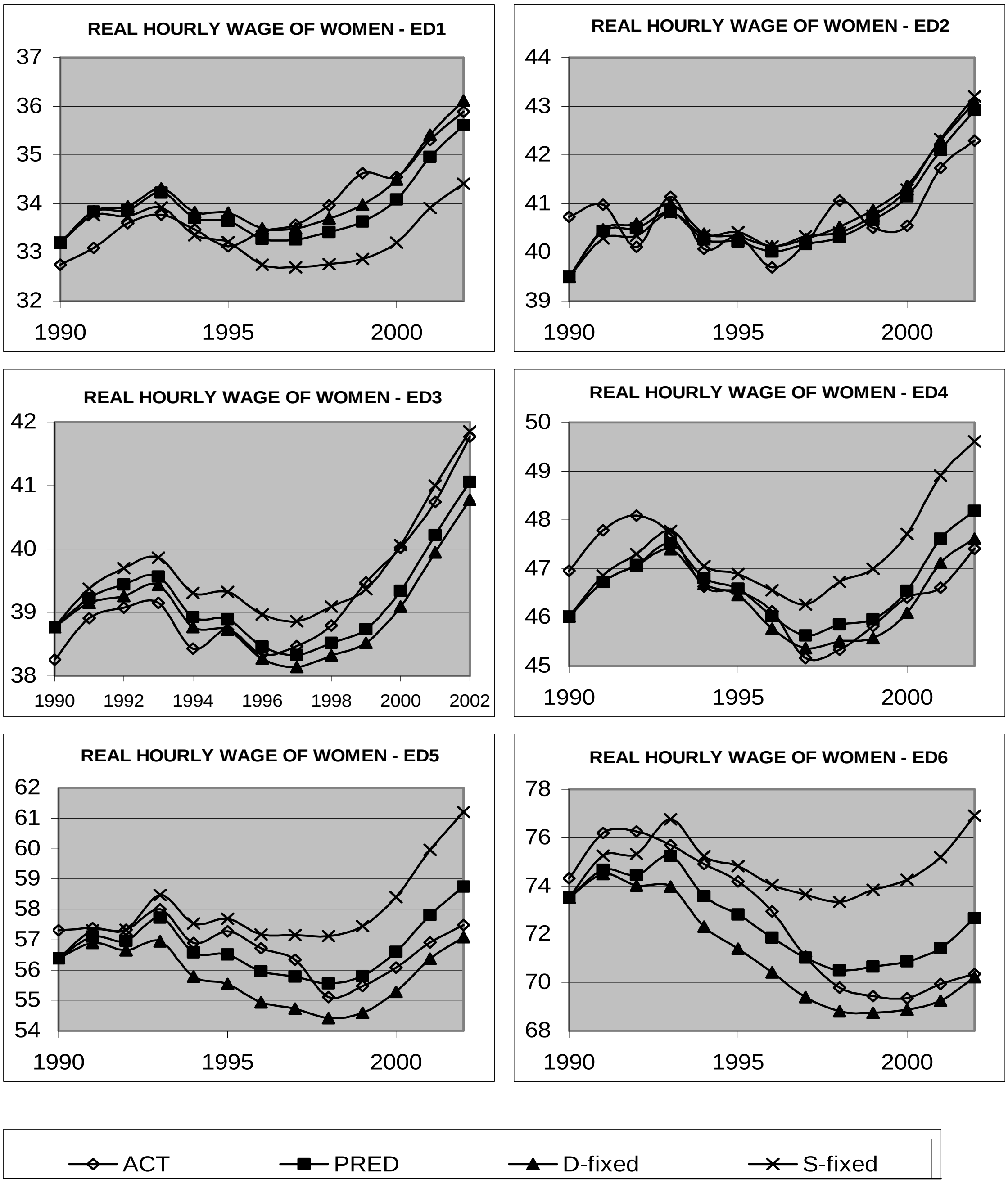
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.22: Real Hourly Wage of Women by Education - France: Actual, Predicted and Simulated Series



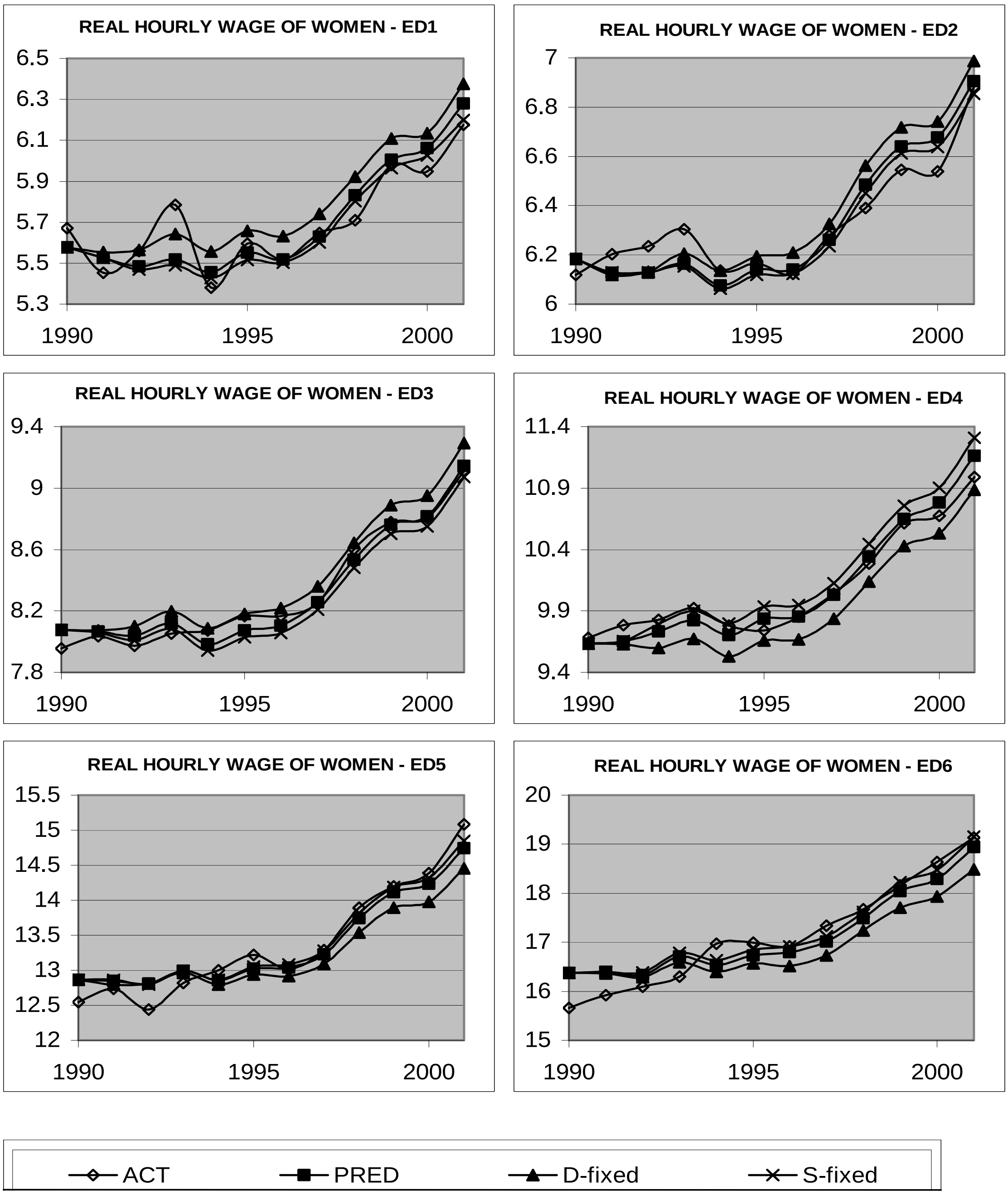
The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.23: Real Hourly Wage of Women by Education - the UK: Actual, Predicted and Simulated Series



The five plots correspond to the five education groups, with ED1 being the least and ED5 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

Figure B.24: Real Hourly Wage of Women by Education - the US: Actual, Predicted and Simulated Series



The six plots correspond to the six education groups, with ED1 being the least and ED6 the most educated. Each plot shows actual values, in-sample predicted values and two sets of simulated values. The "D-fixed" and the "S-fixed" series present the predicted values when the demand shifter or the first supply shifter (i.e. the fraction of the skill-group in the population) are held constant at their initial year values respectively.

C Other Estimation Results

Table C.1: Reduced Form Estimation Results using the Mean of the Observed Wages - Not Weighted

		France 1990-2002			**UK 1993-2002**			**US 1990-2001**		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.09	0.014	-6.21	-0.10	0.043	-2.27	-0.03	0.021	-1.42
	married F	-0.33	0.066	-5.08	-0.11	0.090	-1.19	0.09	0.076	1.13
	married M	0.00	0.058	0.00	0.51	0.107	4.74	0.56	0.067	8.29
	child6 F	0.00	0.050	0.10	0.24	0.132	1.80	0.16	0.101	1.56
	child6 M	0.12	0.050	2.37	-0.06	0.112	-0.53	-0.18	0.100	-1.77
	D shifter	0.04	0.012	3.36	0.07	0.043	1.51	0.06	0.019	3.07
E	lngpop	-0.08	0.013	-5.62	-0.08	0.030	-2.57	-0.23	0.022	-10.38
	married F	-0.28	0.063	-4.47	0.08	0.062	1.36	0.10	0.080	1.21
	married M	0.26	0.055	4.69	0.21	0.074	2.80	0.34	0.071	4.88
	child6 F	-0.07	0.048	-1.49	-0.46	0.091	-5.09	-0.32	0.107	-3.05
	child6 M	0.12	0.048	2.61	-0.20	0.077	-2.62	0.40	0.105	3.82
	D shifter	0.15	0.011	13.03	0.11	0.030	3.73	0.19	0.020	9.10
LS	lngpop	-0.05	0.011	-5.15	-0.09	0.025	-3.75	-0.24	0.019	-12.62
	married F	-0.33	0.049	-6.66	-0.11	0.052	-2.14	0.05	0.069	0.65
	married M	0.23	0.043	5.36	0.20	0.062	3.21	0.39	0.061	6.41
	child6 F	-0.11	0.037	-2.93	-0.39	0.077	-5.12	-0.31	0.093	-3.40
	child6 M	-0.02	0.038	-0.49	-0.06	0.065	-0.98	0.27	0.091	3.02
	D shifter	0.10	0.009	11.38	0.15	0.025	6.02	0.22	0.018	12.29

Note: The three equations - wage equation (W), employment equation (E), and labor force participation equation (LS) - are estimated jointly. Each equation also includes group and year fixed effects. The LHS variable of the wage equation is the logarithm of the *mean* of the observed real hourly wages (CPI base year 1995). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. The rest of the group-level variables were constructed from individual data (weighted by the survey probability weights) as the group proportions or means.

Table C.2: Reduced Form Estimation Results using the Mean of the Observed and Predicted Wage - Not Weighted

		France 1990-2002			UK 1993-2002			US 1990-2001		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.07	0.012	-5.57	-0.08	0.035	-2.28	-0.06	0.018	-3.47
	married F	-0.22	0.057	-3.93	0.15	0.073	2.06	-0.01	0.067	-0.09
	married M	-0.21	0.050	-4.21	0.11	0.086	1.26	0.68	0.060	11.51
	child6 F	0.01	0.043	0.15	0.07	0.107	0.63	0.22	0.090	2.41
	child6 M	0.14	0.043	3.19	-0.04	0.091	-0.40	-0.36	0.088	-4.13
	D shifter	0.05	0.010	4.58	0.08	0.035	2.33	0.10	0.017	6.10
E	lngpop	-0.08	0.013	-5.62	-0.08	0.030	-2.57	-0.23	0.022	-10.38
	married F	-0.28	0.063	-4.47	0.08	0.062	1.36	0.10	0.080	1.21
	married M	0.26	0.055	4.69	0.21	0.074	2.80	0.34	0.071	4.88
	child6 F	-0.07	0.048	-1.49	-0.46	0.091	-5.09	-0.32	0.107	-3.05
	child6 M	0.12	0.048	2.61	-0.20	0.077	-2.62	0.40	0.105	3.82
	D shifter	0.15	0.011	13.03	0.11	0.030	3.73	0.19	0.020	9.10
LS	lngpop	-0.05	0.011	-5.15	-0.09	0.025	-3.75	-0.24	0.019	-12.62
	married F	-0.33	0.049	-6.66	-0.11	0.052	-2.14	0.05	0.069	0.65
	married M	0.23	0.043	5.36	0.20	0.062	3.21	0.39	0.061	6.41
	child6 F	-0.11	0.037	-2.93	-0.39	0.077	-5.12	-0.31	0.093	-3.40
	child6 M	-0.02	0.038	-0.49	-0.06	0.065	-0.98	0.27	0.091	3.02
	D shifter	0.10	0.009	11.38	0.15	0.025	6.02	0.22	0.018	12.29

Note: The three equations - wage equation (W), employment equation (E) and labor force participation equation (LS) - are estimated jointly. Each equation also includes group and year fixed effects. The LHS variable of the wage equation is the logarithm of the *mean* of the real hourly wages (CPI base year 1995) of all the individuals in the skill-group. Wages of individuals who are not working or other missing wages are predicted using the two-equation Heckman model estimated jointly by maximum likelihood (see Section E.2 of the Appendix). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. The rest of the group-level variables were constructed from the individual data, weighted with the survey personal weights, as the group proportions or means.

Table C.3: Reduced Form Estimation Results using the Median of the Observed Wages - Heteroskedasticity-Weighted

		France 1990-2002			UK 1993-2002			US 1990-2001		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.15	0.02	-9.49	-0.07	0.045	-1.59	-0.10	0.022	-4.26
	married F	-0.35	0.08	-4.58	-0.13	0.090	-1.40	0.02	0.079	0.31
	married M	-0.10	0.07	-1.45	0.39	0.112	3.50	0.67	0.068	9.83
	child6 F	-0.01	0.05	-0.23	0.36	0.130	2.77	0.22	0.109	2.00
	child6 M	0.28	0.06	4.98	0.06	0.113	0.53	-0.20	0.108	-1.82
	D shifter	0.09	0.01	6.65	0.04	0.045	0.93	0.09	0.021	4.27
E	lngpop	-0.06	0.01	-5.94	-0.04	0.023	-1.55	-0.03	0.014	-2.25
	married F	-0.27	0.06	-4.28	0.07	0.059	1.15	-0.21	0.061	-3.39
	married M	0.10	0.04	2.70	0.16	0.049	3.31	0.21	0.036	5.92
	child6 F	-0.04	0.05	-0.91	-0.40	0.092	-4.36	-0.21	0.090	-2.32
	child6 M	0.11	0.03	4.29	-0.09	0.046	-2.00	0.01	0.050	0.11
	D shifter	0.10	0.01	10.54	0.04	0.023	1.56	0.02	0.013	1.24
LS	lngpop	-0.04	0.01	-6.03	-0.06	0.016	-3.90	-0.04	0.011	-3.60
	married F	-0.34	0.05	-7.26	-0.15	0.054	-2.75	-0.25	0.055	-4.60
	married M	0.07	0.02	3.79	0.04	0.031	1.19	0.22	0.028	7.80
	child6 F	-0.06	0.03	-1.90	-0.33	0.085	-3.83	-0.14	0.081	-1.71
	child6 M	-0.01	0.01	-0.89	-0.03	0.029	-0.91	-0.06	0.037	-1.55
	D shifter	0.06	0.01	9.05	0.09	0.016	5.29	0.04	0.011	3.50

Note: Variables are first transformed by appropriate weights (see Section E.1 of the Appendix), so as to eliminate the group-wise heteroskedasticity. The three equations - wage equation (W), employment equation (E) and labor force participation equation (LS) - are estimated jointly. The LHS variable of the wage equation is the logarithm of the *median* of the observed real hourly wages (CPI base year 1995). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. The rest of the group-level variables were constructed from the individual data (weighted with the survey probability weights) as the group proportions or means.

Table C.4: Reduced Form Estimation Results using the Median of the Observed and Predicted Wage - Heteroskedasticity-Weighted

		France 1990-2002			**UK 1993-2002**			**US 1990-2001**		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.08	0.01	-5.34	-0.08	0.045	-1.88	-0.13	0.023	-5.64
	married F	-0.32	0.07	-4.48	0.48	0.088	5.46	-0.52	0.082	-6.38
	married M	-0.31	0.06	-4.94	-0.30	0.112	-2.69	1.21	0.071	17.01
	child6 F	0.03	0.05	0.61	-0.11	0.126	-0.87	0.39	0.114	3.44
	child6 M	0.06	0.05	1.07	0.18	0.113	1.57	-0.64	0.113	-5.64
	D shifter	0.06	0.01	4.56	0.11	0.044	2.49	0.14	0.022	6.31
E	lngpop	-0.06	0.01	-5.97	-0.03	0.023	-1.50	-0.03	0.014	-2.15
	married F	-0.27	0.06	-4.17	0.07	0.059	1.20	-0.20	0.061	-3.32
	married M	0.10	0.04	2.52	0.15	0.049	3.01	0.22	0.036	6.19
	child6 F	-0.03	0.05	-0.76	-0.40	0.091	-4.35	-0.21	0.090	-2.35
	child6 M	0.11	0.03	4.16	-0.09	0.046	-1.97	0.00	0.050	-0.04
	D shifter	0.10	0.01	10.58	0.04	0.023	1.59	0.02	0.013	1.19
LS	lngpop	-0.04	0.01	-6.10	-0.06	0.016	-3.85	-0.04	0.011	-3.29
	married F	-0.34	0.05	-7.22	-0.14	0.054	-2.65	-0.24	0.055	-4.44
	married M	0.07	0.02	3.82	0.03	0.031	0.82	0.23	0.028	8.41
	child6 F	-0.06	0.03	-1.85	-0.32	0.085	-3.83	-0.15	0.081	-1.90
	child6 M	-0.01	0.01	-0.92	-0.03	0.029	-0.88	-0.08	0.037	-2.08
	D shifter	0.06	0.01	9.06	0.09	0.016	5.35	0.04	0.011	3.31

Note: Variables are first transformed by appropriate weights (see Section E.1 of the Appendix), so as to eliminate the group-wise heteroskedasticity. The three equations - wage equation (W), employment equation (E) and labor force participation equation (LS) - are estimated jointly. The LHS variable of the wage equation is the logarithm of the *median* of the real hourly wages (CPI base year 1995) of all the individuals in the skill-group. Wages of individuals who are not working or other missing wages are predicted using the two-equation Heckman model estimated jointly by maximum likelihood (see Section E.2 of the Appendix). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. The rest of the group-level variables were constructed from the individual data (weighted with the survey probability weights) as the group proportions or means.

Table C.5: Reduced Form Estimation Results using the Median of the Observed Wages - Not Weighted

		France 1990-2002			UK 1993-2002			US 1990-2001		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.11	0.016	-6.61	-0.10	0.047	-2.12	-0.06	0.023	-2.66
	married F	-0.34	0.075	-4.61	-0.11	0.099	-1.14	0.07	0.082	0.81
	married M	-0.06	0.065	-0.99	0.48	0.117	4.06	0.56	0.073	7.68
	child6 F	0.02	0.057	0.38	0.36	0.145	2.45	0.16	0.110	1.43
	child6 M	0.21	0.057	3.72	0.02	0.123	0.13	-0.25	0.108	-2.27
	D shifter	0.06	0.013	4.43	0.06	0.048	1.31	0.08	0.021	3.57
E	lngpop	-0.08	0.013	-5.62	-0.08	0.030	-2.57	-0.23	0.022	-10.38
	married F	-0.28	0.063	-4.47	0.08	0.062	1.36	0.10	0.080	1.21
	married M	0.26	0.055	4.69	0.21	0.074	2.80	0.34	0.071	4.88
	child6 F	-0.07	0.048	-1.49	-0.46	0.091	-5.09	-0.32	0.107	-3.05
	child6 M	0.12	0.048	2.61	-0.20	0.077	-2.62	0.40	0.105	3.82
	D shifter	0.15	0.011	13.03	0.11	0.030	3.73	0.19	0.020	9.10
LS	lngpop	-0.05	0.011	-5.15	-0.09	0.025	-3.75	-0.24	0.019	-12.62
	married F	-0.33	0.049	-6.66	-0.11	0.052	-2.14	0.05	0.069	0.65
	married M	0.23	0.043	5.36	0.20	0.062	3.21	0.39	0.061	6.41
	child6 F	-0.11	0.037	-2.93	-0.39	0.077	-5.12	-0.31	0.093	-3.40
	child6 M	-0.02	0.038	-0.49	-0.06	0.065	-0.98	0.27	0.091	3.02
	D shifter	0.10	0.009	11.38	0.15	0.025	6.02	0.22	0.018	12.29

Note: The three equations - wage equation (W), employment equation (E), and labor force participation equation (LS) - are estimated jointly. Each equation also includes group and year fixed effects. The LHS variable of the wage equation is the logarithm of the *median* of the observed real hourly wages (CPI base year 1995). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. The rest of the group-level variables were constructed from individual data (weighted by the survey probability weights) as the group proportions or means.

Table C.6: Reduced Form Estimation Results using the Median of the Observed and Predicted Wage - Not Weighted

		France 1990-2002			UK 1993-2002			US 1990-2001		
		coeff	SE	t-stat	coeff	SE	t-stat	coeff	SE	t-stat
W	lngpop	-0.03	0.014	-2.42	-0.10	0.041	-2.42	-0.11	0.023	-4.81
	married F	-0.36	0.067	-5.37	0.32	0.086	3.75	-0.27	0.082	-3.29
	married M	-0.24	0.059	-4.11	-0.17	0.102	-1.62	0.96	0.073	13.10
	child6 F	0.03	0.051	0.65	-0.06	0.126	-0.47	0.40	0.110	3.58
	child6 M	0.09	0.051	1.76	0.06	0.107	0.52	-0.65	0.108	-6.00
	D shifter	0.03	0.012	2.89	0.12	0.041	2.94	0.14	0.021	6.74
E	lngpop	-0.08	0.013	-5.62	-0.08	0.030	-2.57	-0.23	0.022	-10.38
	married F	-0.28	0.063	-4.47	0.08	0.062	1.36	0.10	0.080	1.21
	married M	0.26	0.055	4.69	0.21	0.074	2.80	0.34	0.071	4.88
	child6 F	-0.07	0.048	-1.49	-0.46	0.091	-5.09	-0.32	0.107	-3.05
	child6 M	0.12	0.048	2.61	-0.20	0.077	-2.62	0.40	0.105	3.82
	D shifter	0.15	0.011	13.03	0.11	0.030	3.73	0.19	0.020	9.10
LS	lngpop	-0.05	0.011	-5.15	-0.09	0.025	-3.75	-0.24	0.019	-12.62
	married F	-0.33	0.049	-6.66	-0.11	0.052	-2.14	0.05	0.069	0.65
	married M	0.23	0.043	5.36	0.20	0.062	3.21	0.39	0.061	6.41
	child6 F	-0.11	0.037	-2.93	-0.39	0.077	-5.12	-0.31	0.093	-3.40
	child6 M	-0.02	0.038	-0.49	-0.06	0.065	-0.98	0.27	0.091	3.02
	D shifter	0.10	0.009	11.38	0.15	0.025	6.02	0.22	0.018	12.29

Note: The three equations - wage equation (W), employment equation (E) and labor force participation equation (LS) - are estimated jointly. Each equation also includes group and year fixed effects. The LHS variable of the wage equation is the logarithm of the *median* of the real hourly wages (CPI base year 1995) of all the individuals in the skill-group. Wages of individuals who are not working or other missing wages are predicted using the two-equation Heckman model estimated jointly by maximum likelihood (see Section E.2 of the Appendix). The demand shifter is the logarithm of the skill-group's share in the total value added produced in the economy in the current year. The rest of the group-level variables were constructed from the individual data, weighted with the survey personal weights, as the group proportions or means.

D Model Details

D.1 Correspondences between the structure and the reduced form

Correspondences between the estimated reduced form parameters and the structural parameters are given in Table D.1.

Table D.1:
Correspondences between the Reduced Form and the Structural Parameters

$\mathbf{i = w, e, s}$	$\ln(\mathbf{w_j})$	$\ln(\mathbf{e_j})$	$\ln(\mathbf{l^s_j})$
$\pi^{i}_{\tilde{c}}$	$\frac{\rho\,(\sigma-1)}{\sigma+\varepsilon}\,\lambda_1$	$(\sigma-1)\big[1-\frac{\sigma\,\rho}{\sigma+\varepsilon}\big]\,\lambda_1$	$\frac{\varepsilon\,\rho\,(\sigma-1)}{\sigma+\varepsilon}\,\lambda_1$
π^{i}_{p}	$-\,\frac{\rho}{\sigma+\varepsilon}$	$-\big(1-\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)$	$-\,\frac{\varepsilon\,\rho}{\sigma+\varepsilon}$
$\pi^{f\,i}_{m}$	$-\,\big(\frac{\rho}{\sigma+\varepsilon}\big)\,\beta^{f}$	$\big(\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)\,\beta^{f}$	$\big(1-\frac{\varepsilon\,\rho}{\sigma+\varepsilon}\big)\,\beta^{f}$
$\pi^{m\,i}_{m}$	$-\,\big(\frac{\rho}{\sigma+\varepsilon}\big)\,\beta^{m}$	$\big(\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)\,\beta^{m}$	$\big(1-\frac{\varepsilon\,\rho}{\sigma+\varepsilon}\big)\,\beta^{m}$
$\pi^{f\,i}_{k}$	$-\big(\frac{\rho}{\sigma+\varepsilon}\big)\,\gamma^{f}$	$\big(\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)\,\gamma^{f}$	$\big(1-\frac{\varepsilon\,\rho}{\sigma+\varepsilon}\big)\,\gamma^{f}$
$\pi^{m\,i}_{k}$	$-\big(\frac{\rho}{\sigma+\varepsilon}\big)\,\gamma^{m}$	$\big(\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)\,\gamma^{m}$	$\big(1-\frac{\varepsilon\,\rho}{\sigma+\varepsilon}\big)\,\gamma^{m}$

The estimated skill group and year fixed effect correspond to the structural parameters as follows:

$$
\begin{aligned}
\pi^{w}_{1j} &= \omega_j - \frac{\rho}{\sigma+\varepsilon}\,\alpha_j \\
\pi^{e}_{1j} &= \frac{\sigma\,\rho}{\sigma+\varepsilon}\,\alpha_j - \sigma\,\omega_j \\
pi^{s}_{1j} &= \big(1-\frac{\varepsilon\,\rho}{\sigma+\varepsilon}\big)\,\alpha_j + \varepsilon\,\omega_j \\
\tilde{\pi}^{w}_{0t} &= \eta_t + \frac{\rho}{\sigma+\varepsilon}\Big(\ln(y_t) + (\sigma-1)\,\lambda_{0\,t}\Big) \\
\tilde{\pi}^{e}_{0t} &= \ln(y_t) - \sigma\,\eta_t + (\sigma-1)\big(1-\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)\,\lambda_{0\,t} \\
\tilde{\pi}^{s}_{0t} &= \varepsilon\,\eta_t + \frac{\varepsilon\,\rho}{\sigma+\varepsilon}\Big(\ln(y_t) + (\sigma-1)\,\lambda_{0\,t}\Big)
\end{aligned}
$$

The reduced form error terms map into the structural error terms as follows

$$\begin{aligned}
\xi_{jt}^{w} &= \frac{\rho}{\sigma+\varepsilon}\,(\nu_{jt}^{d}-\nu_{jt}^{s})\,+\nu_{jt}^{w} \\
\xi_{jt}^{e} &= \frac{\sigma\,\rho}{\sigma+\varepsilon}\,\nu_{jt}^{s}-\sigma\,\nu_{jt}^{w}+\big(1-\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)\,\nu_{jt}^{d} \\
\xi_{jt}^{s} &= \frac{\varepsilon\,\rho}{\sigma+\varepsilon}\,\nu_{jt}^{d}+\varepsilon\,\nu_{jt}^{w}+\big(1-\frac{\varepsilon\,\rho}{\sigma+\varepsilon}\big)\,\nu_{jt}^{s}
\end{aligned}$$

When the demand shifter $\tilde{c}_{jt}$ is used instead of the unobserved relative coefficient c_{jt}, the reduced form error terms become

$$\begin{aligned}
\tilde{\xi_{jt}^{w}} &= \frac{\rho}{\sigma+\varepsilon}\,(\nu_{jt}^{d}-\nu_{jt}^{s})\,+\nu_{jt}^{w}\,+\frac{\rho\,(\sigma-1)}{\sigma+\varepsilon}\,\nu_{jt}^{c} \\
\tilde{\xi_{jt}^{e}} &= \frac{\sigma\,\rho}{\sigma+\varepsilon}\,\nu_{jt}^{s}-\sigma\,\nu_{jt}^{w}+\big(1-\frac{\sigma\,\rho}{\sigma+\varepsilon}\big)\,\nu_{jt}^{d}\,+(\sigma-1)\big[1-\frac{\sigma\,\rho}{\sigma+\varepsilon}\big]\,\nu_{jt}^{c} \\
\tilde{\xi_{jt}^{s}} &= \frac{\varepsilon\,\rho}{\sigma+\varepsilon}\,\nu_{jt}^{d}+\varepsilon\,\nu_{jt}^{w}+\big(1-\frac{\varepsilon\,\rho}{\sigma+\varepsilon}\big)\,\nu_{jt}^{s}\,+\frac{\varepsilon\,\rho\,(\sigma-1)}{\sigma+\varepsilon}\,\nu_{jt}^{c}
\end{aligned}$$

D.2 Identification

The system of structural equations is given by

$$\begin{aligned}
\ln(l_{jt}^{d}) &= \ln(y_t)-\sigma\ \ln(w_{jt})+(\sigma-1)\ \ln(c_{jt})-\ln(p_{jt})+\nu_{jt}^{d} \\
\ln(l_{jt}^{s}) &= \alpha_j+\varepsilon\ \ln(w_{jt})+\beta^{g}\ m_{jt}+\gamma^{g}\ k_{jt}+\nu_{jt}^{s} \\
l_{jt}^{s}(w_{jt}^{*}) &\equiv l_{jt}^{d}(w_{jt}^{*}) \\
\ln(w_{jt}) &= \eta_t+\omega_j+\rho\ \ln(w_{jt}^{*})+\nu_{jt}^{w} \\
u_{jt} &\equiv l_{jt}^{s}-l_{jt}^{d} \\
e_{jt} &\equiv l_{jt}^{d} \\
1 &\equiv e_{jt}+u_{jt}+n_{jt}
\end{aligned}$$

This system simplifies to (omitting the time subscripts)

$$\begin{aligned}
\ln(e_j) &= \ln(y)-\sigma\ \ln(w_j)+(\sigma-1)\ \ln(c_j)-\ln(p_j)+\nu_j^{d} \\
\ln(l_j^{s}) &= \alpha_j+\varepsilon\ \ln(w_j)+\beta^{g}\ m_j+\gamma^{g}\ k_j+\nu_j^{s} \\
\ln(w_j) &= \eta+\omega_j+\rho\,\frac{1}{\varepsilon+\sigma}\,\Big[ln(y)-\alpha_j-\beta^{g}\ m_j-\gamma^{g}\ k_j+(\sigma-1)\ \ln(c_j)-\ln(p_j)+\nu_j^{d}-\nu_j^{s}\Big]+\nu_j^{w} \\
1 &\equiv l_j^{s}+n_j
\end{aligned}$$

The way the model is set up and the substantial number of parameters (including the group and the year effects as described in the Section D.1) makes the traditional proof of identification through the rank and order conditions rather complicated. Therefore in what follows, I use an easier method of step by step description of how the key structural parameters could be recovered from particular reduced form estimates.

The key structural parameters can be inferred for example as follows. The ratio of the coefficient of the proportion of the group in the population from the labor force participation equation to the same coefficient in the wage equation gives the wage elasticity of labor supply.[61] The ratio of the coefficient of the presence of pre-school children for women in the employment equation to the one in the wage equation can be used to calculate σ. The coefficient of the group's proportion within the population in the wage equation and the previous estimates of ε and σ enable to construct ρ. The four structural coefficients of the exogenous labor supply shifters can be recovered for example from the reduced form estimates from the wage equation alone: They are equal to the ratio of the respective gender-specific coefficients of the variables describing marital status and children, and the coefficient of the proportion of the group in the population. The coefficient of the instrument of the relative efficiency (λ_1) is minus the ratio of the demand shifter and the population fraction coefficients from the wage equation, divided by $(\sigma - 1)$. We can plug in the expression for σ as derived before. All the formulas are summarized below.

$$
\begin{aligned}
\varepsilon &= \frac{\pi_p^s}{\pi_p^w} \quad ; \quad \sigma = -\frac{\pi_k^{f\,e}}{\pi_k^{f\,w}} \\
\rho &= -\pi_p^w\,(\sigma+\varepsilon) = -\pi_p^w\left(-\frac{\pi_k^{f\,e}}{\pi_k^{f\,w}} + \frac{\pi_p^s}{\pi_p^w}\right) \\
\beta^f &= \frac{\pi_m^{f\,w}}{\pi_p^w} \quad ; \quad \beta^m = \frac{\pi_m^{m\,w}}{\pi_p^w} \\
\gamma^f &= \frac{\pi_k^{f\,w}}{\pi_p^w} \quad ; \quad \gamma^m = \frac{\pi_k^{m\,w}}{\pi_p^w} \\
\lambda_1 &= -\frac{\pi_{\tilde{c}}^w}{\pi_p^w}\left(\frac{1}{\sigma-1}\right) = \left(\frac{\pi_{\tilde{c}}^w}{\pi_p^w}\right)\left(\frac{\pi_k^{f\,w}}{\pi_k^{f\,w}+\pi_k^{f\,e}}\right)
\end{aligned}
$$

Alternatively, ε and ρ can be derived for example from any two of the coefficients from the wage equation, once the other parameters are derived as above. In this way, estimation of only wage and employment equations is sufficient for the identification.

[61] The same is true for the corresponding ratio of the two coefficients of the demand shifter.

E Estimation Details

E.1 Heteroskedasticity-Adjustment Weights and Their Derivation

In the preferred specification, the group-level variables are transformed with appropriate weights to adjust for heteroskedasticity present in the model due to the way the group-level data are constructed.

The variables in the wage equation are multiplied by the weight for the grouped data. When the group wage is constructed as simple mean[62] of the observed or predicted wages, the weight is

$$weight_j = \sqrt{N_{jt}}$$

where N_{jt} is the size of group j in year t.[63] When the group wage is constructed as weighted average of the observed or predicted wages using the sample probability weights, the weight to adjust for heteroskedasticity is

$$weight_j = \sqrt{\frac{W_{jt}^2}{\sum_i w_{ijt}^2}}$$

where w_{ijt} is the sample probability weight of individual i in group j in year t and $W_{jt} = \sum_i w_{ijt}$ size of group j in year t.

This weight is derived as follows. Assume $y_{ij} \sim N(\mu, \sigma^2)$, i.e. $y_{ij} = \mu + u_{ij}$. The sample probability weighted mean is $\bar{y_j} = \frac{\sum_i w_{ij} y_{ij}}{W_j}$ and the mean error term is $\bar{u_j} = \frac{\sum_i w_{ij} u_{ij}}{W_j}$. The variance of $\bar{u_j}$ is then

$$var(\bar{u_j}) = \frac{\sum_i w_{ij}^2 \, var(y_{ij})}{W_j^2} = \sigma^2 \frac{\sum_i w_{ij}^2}{W_j^2}$$

The appropriate weight is the inverse of the square-root of the heteroskedastic part of the variance of $\bar{u_j}$.

The variables in the employment equation are multiplied by the weight for the proportion data in the log-linear model, as derived in Maddala (1983, p.29). When the group employment is constructed as a simple proportion, the weight is

$$weight_j = \sqrt{\frac{N_{jt} \, p_{jt}}{(1 - p_{jt})}}$$

[62] We apply the same weights also when using median of the observed or predicted wages for the group wage. Although this is not formally correct, we believe at this point that the weights provide a sufficient approximation which is also much simpler than would be the weights derived for the median.

[63] When the group-specific wage is constructed, as will be described later, as the mean or median of the observed wages only (without imputing wages for the non-workers, self-employed and the employed with missing wage information), I use the number of the wages used to produce the group statistic rather than the total number of individuals in the group.

where N_{jt} is the size of group j in year t and p_{jt} is the proportion of employed individuals in group j in year t.

When the group employment is constructed as weighted proportions using the sample probability weights, the weight used to transform the variables in the employment equation is

$$weight_j = \sqrt{\frac{W_{jt}^2}{\sum_i w_{ijt}^2} \; \frac{p_{jt}}{(1-p_{jt})}}$$

where the terms in this expression are defined as above.

This weight is derived as follows. Assume $\ln(\hat{p_j}) = \ln(p_j) + u_j$, where $\hat{p_j} = \frac{\sum_{ij} w_{ij} I_{ij}}{W_j}$ is the sample probability weighted proportion of individuals who are employed and I_{ij} is an indicator that equals one if the individual is employed and zero otherwise. Assuming that $I_{ij} = 1$ with probability p_j,

$$var(\hat{p_j}) = \frac{\sum_i w_{ij}^2 \, var(I_{ij})}{W_j^2} = \frac{p_j\,(1-p_j)\,\sum_i w_{ij}^2}{W_j^2}$$

Expanding $\ln(\hat{p_j})$ around p_j in a Taylor series implies $u_j \simeq \frac{(\hat{p_j}-p_j)}{p_j}$, so that

$$var(u_j) =\simeq \frac{var(\hat{p_j})}{p_j^2} = \frac{(1-p_j)}{p_j} \; \frac{\sum_i w_{ij}^2}{W_j^2}$$

The appropriate weight is the square-root of the inverse of the variance of u_j.

The weights for the employment equation apply also to the labor force participation equation, with I_{ij} indicating whether an individual is in the labor force.

E.2 Prediction of the Unobserved Wages

In the preferred specification, the group specific wage is constructed as mean or median of wages of all the individuals in the group. In this case wages for the individuals for which the wage information is missing must be imputed. The analysis predicts wages to people with missing wage information using the traditional two-equation model of Heckman. The following wage equation is estimated along with the employment equation to account for the potential selection to employment based on unobservable characteristics.

$$\begin{aligned} \ln(w_i) &= X_i\beta + \varepsilon_i \\ I_i &= Z_i\gamma + \upsilon_i \end{aligned}$$

ε_i and υ_i have a bivariate normal distribution with zero means and covariance matrix Σ, w_i is individual's i wage and I_i is a zero/one indicator function specifying whether wage is observed for the individual i or not.

The two equations are estimated jointly by maximum likelihood. Sample probability weights were used in the estimation. The right-hand-side variables in the wage equation (X_i) are age, age squared, dummy variables for the six (five in the UK) education categories, ethnicity,[64] immigration status (stating whether the individual was born in another country), and an indicator whether the individual is full-time employed. The exclusion restrictions (variables that are in the selection equation but not in the wage equation) are the marital/cohabitating status and the presence of pre-school age children in the household. The model is estimated separately for men and women, and the estimation is done by year. The model is used to predict wages to individuals for which wages are unobserved. The group specific wage is constructed as the median or mean of the wages of all individuals, using the reported actual wages of those who have the wage information, and the predicted wages of those who don't.

E.3 The Minimum Distance Method

The minimum distance method that was used to recover the structural parameters from the reduced form estimates is described in this section. Vector of structural parameters θ is a solution to the optimization problem

$$\hat{\theta} = \arg\min_{\theta} \, (\hat{\pi} - h(\theta))' \, \hat{W} \, (\hat{\pi} - h(\theta))$$

where $\hat{\theta}$ is the resulting vector of the key structural parameters (σ, ε, ρ, β^f, β^m, γ^f, γ^m), $\hat{W}$ is a weighting matrix, $\hat{\pi}$ is the vector of the estimates of the reduced form coefficients, and $h(\theta)$ is the vector of the functions that map the reduced form parameter estimates to the structural parameters. There are 18 reduced form estimates in the model and 18 corresponding functions, which are are summarized in Table D.1.

Depending on the choice of W, there are two versions of this method. Equally weighted minimum distance method (EWMD) assigns the same weight to each moment, as it uses $\hat{W} = I$ where I is the identity matrix. Optimal minimum distance method (OMD), which is also known as the generalized method of moments (GMM) uses the inverse of the covariance matrix of the eighteen estimated coefficients as the weighting matrix. OMD therefore assigns more weight to the moments that are estimated more precisely, i.e. that have smaller variance.

Standard errors were calculated by delta method as follows. The covariance matrix of the estimated structural parameters is given by

$$var(\hat{\theta}) = \left(\Gamma_n'(\hat{\theta}) \; \hat{W} \; \Gamma_n(\hat{\theta})\right)^{-1}$$

where N is the sample size, $\hat{W}$ is the inverse of the covariance matrix of the eighteen estimated reduced form coefficients, and $\Gamma_n(\hat{\theta})$ is the matrix of partial derivatives of the eighteen moments evaluated at $\hat{\theta}$.

[64] This variable is not present in the French dataset and therefore is not used in the estimation for France.