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# IAB-Discussion Paper

20/2011

Articles on labour market issues

## The gender gap of returns on education across West European countries

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## Abstract

We study the returns on education in Europe in a comparative perspective. We extend the model of de la Fuente [(2003). Human Capital in a Global and Knowledge-based Economy. part II: Assessment at the EU Country Level. Report for the European Commission], by estimating the values of the relevant parameters for men and women and introducing several variables specifically related to maternity leaves and benefits. As a preliminary step, we evaluate the effect of education on the wage profile. We estimate the Mincerian coefficients for 12 West European countries using the EU-SILC data for 2007 and use them as input in the optimisation problem of the individual to calibrate the model. Finally, we analyse the impact and relevance of several public policy variables. In particular, we evaluate the elasticities of the returns to education with respect to unemployment benefits, marginal and average tax rates, maternity leave and childcare benefits.

## Zusammenfassung

Wir untersuchen die Bildungserträge in Europa in vergleichender Perspektive. Wir erweitern dazu das Modell von de la Fuente [(2003). Human Capital in a Global and Knowledge-based Economy. part II: Assessment at the EU Country Level. Report for the European Commission], indem wir die relevanten Parameter für Männer und Frauen schätzen und einige Variablen für staatliche Leistungen bei Eltern- oder Erziehungsurlaub und für Kinderbetreuung einführen. Daneben untersuchen wir den Einfluss der Bildung auf das Lohnprofil. Wir schätzen die Mincer-Koeffizienten für 12 westeuropäische Länder mit den EU-SILC-Daten für 2007 und nutzen sie als Input zur Kalibrierung eines Modells des Optimierungsproblem eines Individuums. Schließlich analysieren wir die Auswirkung und Relevanz verschiedener Politikbereiche. Insbesondere schätzen wir die Elastizitäten der Bildungserträge im Hinblick auf Änderungen der Arbeitslosenunterstützung, der marginalen und durchschnittlichen Steuersätze und Leistungen bei Mutterschaft und für Kinderbetreuung.

**JEL classification:** I21

**Keywords:** human capital, rate of return, public policy

## Acknowledgements

We wish to thank S. Black, M. Belot, S. Capuano, B. Cockx, D. de la Croix, G. Heineck, J. Ludsteck, N. Nisic, T. Pietra, V. Vandenberghe, P. Vitale, F. Yaman, and participants in the seminars held at the IAB, Universities of Bologna, Lille 2 and IRES-UCL for their helpful comments. The authors would also like to thank S. Bähr for his research assistance. The responsibility for any remaining mistakes is our own.

# 1 Introduction

In the economic literature, human capital accumulation has been identified as one of the most relevant engines of economic growth. Also, changes in the skill premium have often been identified as an important factor affecting the dynamics of income distribution. Moreover, human capital and, first and foremost, the level of formal education have frequently been seen as one of the most important factors affecting many dimensions of social life, including the structure and dynamics of the family and fertility patterns. These are some of the motivations behind the large literature studying levels and dynamics of the returns on education. In this paper, we contribute to this literature by providing some additional evidence on the returns to education in several European countries. Our contribution has four distinctive features. First, we compute the rates of return using a well-specified theoretical model of individual choice, which allows us to take into account and to assess the significance of some of the different relevant variables: the wage premium, the structure of income tax and of some public transfers and benefits, and the costs of the investments in education. Secondly, we provide separate results for men and women. Thirdly, we estimate the wage premia using EU Survey on Income and Living Conditions data (2007), which improve upon the quality of the data previously available for a comparative analysis at European level. Finally, we consider 12 different EU countries, spanning quite different situations in terms of labour market conditions and public policies.

Concerning the first point, several papers compute the rate of returns on education embedding the wage premia in models, taking into account some of the other relevant variables (see, for instance, Barceinas-Paredes, Oliver-Alonso, Raymond-Bara, Roig-Sabaté and Weber (2000), Blondal, Field and Girouard (2002), and Heckman, Lochner and Todd (2008)). Our theoretical model builds on that proposed by de la Fuente (2003) and de la Fuente and Jimeno (2008). The first report (2003), written on behalf of the European Commission, provides a comparative analysis of private and social returns on education in 14 European countries. It specifies the investment in education as the optimal solution to a well-defined individual optimisation problem which takes into account wage premium, labour income taxes, costs of education and incidence of unemployment – at different educational levels – and unemployment benefits. The report uses different sets of data to compute the returns on education across European countries. The main findings are that educational attainments are a key determinant of individual earnings and aggregate productivity and that human capital is an attractive investment from both the microeconomic and the macroeconomic points of view. The same basic model has also been adopted in several country studies (see de la Croix and Vanderberghe (2004) for Belgium, Ciccone (2004) for Italy and de la Fuente, Jimeno and Domenech (2003) for Spain). More recently, de la Fuente and Jimeno (2008) focus on the fiscal returns to education in European countries and, using different simulated scenarios, evaluate the impact of several public policies. All these papers provide gender-free estimates. Conversely, we compute separately the returns on education of men and women

entering the job market at the end of their formal education and exiting the job market at the average age of retirement. The obvious motivation for this disaggregation by gender is that the lifetime experiences of men and women differ for many reasons. For instance, the wage profiles of men and women are different; the gender-specific rates of unemployment are different; the length of their active lives are different; unemployment benefits are (or may be) different, due (mostly) to wage differences; public policies affect men and women in different ways. Gender-specific returns on education have been computed, using de la Fuente's model, for 21 OECD countries by Boarini and Strauss (2010). We also adopt his 2003 model to estimate the returns on education for men. However, to study all the possible factors driving the gender gap in the rates of return, we take the de la Fuente model one step further by also considering some parameters related to maternity issues that can affect the incentive to invest in education and to participate to the labour market for women (see Del Boca, Locatelli, Pasqua and Pronzato (2003)). Hence, our model differs from that of Boarini and Strauss (2010) mainly in how it deals with women (and for the econometric procedure adopted in the estimate of the Mincerian coefficients that they use). The actual female work experience may be affected by maternity episodes and, consequently, by maternity leave and maternity-related monetary benefits (Mac (2003), Mahon (2002), Brewster and Rindfuss (2000), Blackburn, Bloom and Neumark (1993)). Therefore, maternity accounts for several differences in the working lives of men and women. Potentially, it also has some consequences related to the female-specific rates of return because of the correlation that may exist between education and fertility. The (negative) relationship between these two variables is often taken for granted. While there are many studies on this subject (and corroborating this claim) referring to developing countries, there seems to be relatively little empirical evidence on this issue in economically advanced countries in a comparative perspective. Unfortunately, the EU-SILC data do not provide the information required to compute the fertility rates directly.<sup>1</sup> Using evidence from a non-homogeneous source that can adopt different definitions, actual vs. expected fertility rates, may introduce measurement errors and bias. Hence, in this paper, unlike with standard macro-estimations, we exploit some evidence based on the UNCE "Family and Fertility Studies" referring to several European countries to evaluate the relationship between education and fertility. These reports provide, on a comparable basis, information on fertility rates, broken down by education levels and, thus, they provide one of the main ingredients for the estimates. It turns out that, indeed, there is a negative correlation between education and fertility.

One of the key building blocks for our analysis is the estimates of the wage premia. The EU-SILC data give us the opportunity to use recent and comparable micro-data to estimate the cross-country differences in the returns on education. We will dis-

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<sup>1</sup> The data only report the total number of children in the household. In the literature, many references are to Jones (1982) and, somewhat improperly, to the United Nations (1995, a study just referring to developing countries).

discuss the data in more detail in Section 3. Using the EU-SILC data (2007), we estimate the Mincerian coefficients (Mincer (1974)) for the 12 countries in our sample, separately for men and women. We then embed these as one parameter affecting the individual decision problem, together with several other parameters.

Different policies affect the decision of investing in education in many different ways (see de la Croix, D. and Doepke, M. (2004), Gustafsson, S., Kenjoh, E. and Wetzel, C. (2002)). In general, a comparative analysis taking into account countries with different systems of policy intervention is interesting. We believe that the comparative perspective is particularly useful for dealing with gender-related differences in returns on education because the work experiences of women vary across countries more than those of men.

In addition to our estimates of the Mincerian coefficients, we present our computations of the rates of return and of their elasticities with respect to several policy parameters. They show that, quantitatively, the returns on education depend crucially on the Mincerian components (i.e. wage premia and labour income taxes). Since the unemployment rates by educational levels are different, unemployment benefits also affect the rates of return on education. Similarly, since fertility rates vary with the educational levels, the policies adopted with respect to maternity benefits also have some impact on the rates of return. These two factors are of the same order of magnitude, but they are not as significant as the Mincerian coefficients and labour income taxes. The numerical values of the elasticities also show that the returns to education are sensitive mostly to the factors affecting the Mincerian component of the rates of return: tax rates and wage policies adopted in the public sector.

We conclude by pointing out some of the limits of our analysis. First, differences in the actual policies and benefits adopted in each country are only imperfectly captured by the available data provided by international institutions. This is clearly established by some of the country studies mentioned above. Secondly, there is an unavoidable degree of arbitrariness in computing benefits for a given type of worker. In the paper, we spell out the exact criteria used to select and attribute benefits. Generally speaking, the conventions adopted may lead us to overestimate the female returns on education. Therefore, our estimates essentially provide an upper boundary for the set of 'reasonable' estimates. Thirdly, we ignore any form of general equilibrium consideration. In de la Fuente (2003), the rates of return are defined as the discount rates such that the actual, average level of schooling is the optimal solution to the individual decision problem. Accordingly, the elasticity of the rate of return with respect to, say, unemployment benefits is computed keeping the 'optimal' investment in education fixed. Hence, it provides us with an intuitive measure of the relevance of unemployment benefits in determining the rate of return, but it says nothing about the actual effect on the equilibrium of a change in the benefits.

The set up of the paper is the following. The next section presents the model adopted for men, which also forms the basis of that we adopt to evaluate the returns for women. The third section discusses the data and presents our estimates of the

Mincerian coefficients. In Section 4, we define the additional variables used to calibrate the model, we compute the values, by gender, of the private returns on education. In Section 5, we analyse the impact of several public policies and compute the elasticities of the rates of return with respect to these. Technical details on the derivations of the fundamental formulae are given in the appendices.

## 2 Description of the model

For computing the rates of return on education, we follow the approach proposed by de la Fuente (2003). The structure of his model has the advantage of considering opportunity and direct costs, tax system, employment probability and other variables that can affect the decision of investing in education. Therefore, it allows us to compare how these variables affect individuals in different countries covered in the sample.

Our estimates of the male returns are based exactly on de la Fuente's model. In the estimates for women, the same basic approach will be modified to take into account maternity leave and benefits.

Let us start with the basic model. Consider an individual who studies for  $S$  years and retires at time  $U$ . Let  $S_0$  be the average number of years spent in education. Earnings of a full-time worker with  $S$  years of schooling are given by the product of an increasing function of education,  $f(S)$ , and an exogenous 'technical efficiency index',  $A_t \equiv A_0 e^{gt}$ . Following de la Fuente, we assume that after-tax earnings of an individual in full-time employment are given by  $[f(S) - T(f(S))]A_t$ , i.e. that "tax rates are a function of relative rather than absolute incomes".

If unemployed, individuals obtain net benefits that may or may not be related to their previous earnings and to average earnings,

$$a[f(S) - T(f(S))] + b[f(S_0) - T(f(S_0))].$$

Let  $p(S)$  be the probability of being employed for an agent with  $S$  years of schooling, an increasing function of  $S$ . Then, the discounted lifetime earnings of a male,  $I_M(S)$ , are given by

$$I_M(S) \equiv \int_S^U \left\{ p(t)(f(t) - T(f(t))) + (1 - p(t))[a(f(t) - T(f(t))) + b(f(S_0) - T(f(S_0)))] \right\} A_t e^{-rt} dt$$

Schooling implies direct private costs, denoted by  $C_M(S)$  (estimated, per year, as a fixed fraction  $\mu_s$  of the average earnings of a production worker with  $S_0$  years of schooling). Hence, the (discounted) direct costs of education,  $C_M(S)$ , are given by

$$C_M(S) \equiv \int_0^S \mu_s f(S_0) A_t e^{-rt} dt.$$



Finally, we assume that, while in school, individuals devote a fixed fraction  $\phi$  of their time to studying and attending school. Therefore, their labour supply is given by a fraction  $(1-\phi)$  of the labour supply of full-time workers. Moreover, we assume that students are not entitled to unemployment benefits and that their probability of being employed is a fixed fraction,  $\eta$ , of that of someone available for full-time work. Hence, the present value of the expected lifetime earnings while in school,<sup>2</sup>  $J_M(S)$ , is given by

$$J_M(S) \equiv \int_0^S \eta p(t) [(1-\phi)f(t) - T((1-\phi)f(t))] A_t e^{-rt} dt$$

The present value of the expected net lifetime earnings for men is then

$$V_M(S) = I_M(S) + J_M(S) - C_M(S)$$

We define as private rate of return on education the value  $r$  such that the average level of education  $S_0$  is the optimal solution to the problem of maximising  $V_M(S)$  for the representative (male) agent. Hence,  $r$  is obtained as the value such that  $\frac{\partial V_M(S)}{\partial S} \Big|_{S_0} = 0$ .

Let us define

$$p_0 \equiv p(S_0) \quad \theta \equiv \frac{\frac{\partial f(S)}{\partial S} \Big|_{S_0}}{f(S_0)} \quad \varepsilon \equiv \frac{\frac{\partial p(S)}{\partial S} \Big|_{S_0}}{p(S_0)}$$

$$\tau_0 \equiv \frac{T(f(S_0))}{f(S_0)} \quad T' \equiv \frac{\partial T(f(S))}{\partial S} \Big|_{S_0} \quad \tau_s \equiv \frac{T((1-\phi)f(S_0))}{(1-\phi)f(S_0)}$$

where  $\theta$  is the Mincerian return to schooling parameter,  $\varepsilon$  measures the curvature of the function  $p(S)$  at  $S_0$ , normalised by  $p(S_0)$ ,  $\tau_0$  and  $T'$  are the average and marginal rates of income tax for a full-time worker with education  $S_0$ , while  $\tau_s$  is the average tax rate on the income of a student with education  $S_0$  working part-time. Finally, let  $R \equiv (r - g)$  and  $H \equiv (U - S_0)$ .

Using this notation and by a straightforward manipulation of  $\frac{\partial V_M(S)}{\partial S} \Big|_{S_0} = 0$ , we obtain<sup>3</sup>

<sup>2</sup> Note that we ignore retirement benefits.

<sup>3</sup> That is, equation (9) in de la Fuente (2003, p.13).

$$\frac{R_M}{1 - e^{-R_M H_M}} = \frac{\theta \left[ \frac{p_0 + (1-p_0)a}{p_0 + (1-p_0)(a+b)} \right] \left[ \frac{1-T'}{1-\tau_0} \right] + \varepsilon \left[ \frac{(1-a-b)p_0}{p_0 + (1-p_0)(a+b)} \right]}{\left[ 1 - \frac{1-\tau_s}{1-\tau_0} \frac{(1-\phi)\eta p_0}{p_0 + (1-p_0)(a+b)} \right] + \left[ \frac{\mu_s}{(p_0 + (1-p_0)(a+b))(1-\tau_0)} \right]} \quad (1)$$

We will use (1) to evaluate the private rates of return on education for males. Since the left-hand side of eq. (1) is strictly increasing in  $R_M$ , the larger the value of the right-hand side, the larger the value of  $R_M$ . As specified in the following sections, we will use the values of the parameters referring to the male population to compute  $R_M$ . The main departure from de la Fuente (2003) is that he considers a single male with earnings equal to those of an Average Production Worker (in the sequel, APW). We consider instead a couple with two children where the male has earnings equal to 100% of the Average Worker Wage<sup>4</sup> (AWW), while the female has earning equal to 67% of the AWW. Evidently, marginal and average tax rates ( $\tau_0$  and  $T'$ ), as well as unemployment benefits, are adjusted accordingly.

For female individuals, we modify the basic function  $V(S)$  as follows. Direct private education costs and earnings while in school are determined as above. However, given that female average earnings are estimated at 67% of the AWW, the parameter defining direct private costs of education as a fraction of the female earnings is  $1.5\mu_s$ , so that the actual monetary costs are gender-invariant. Therefore,

$$C_w(S) \equiv \int_0^S 1.5\mu_s f(S_0) A_t e^{-rt} dt$$

and

$$J_w(S) \equiv \int_0^S \eta p(t) [(1-\phi)f(t) - T((1-\phi)f(t))] A_t e^{-rt} dt.$$

The key difference is in the definition of the expected lifetime earnings after school. We explicitly introduce in the function  $I_w(S)$  maternity and parental leave and child benefits as follows: let  $q(S)$  be the fraction of the (full-time) working life (of length  $H$ ) when the representative woman does not have maternity leave. Evidently,  $(1-q(S))$  will depend upon the number of children,  $c$ , divided by the number of women,  $W$ , and upon the length of (paid or unpaid) maternity leave allowed by law,  $d$ , i.e.

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<sup>4</sup> Up until 2004, the OECD reported the APW in its annual series *Taxing Wages*. Starting with the 2005 edition, the APW was replaced by the AWW. Compared to the APW, the AWW is based on a broader set of sectors, also including service sectors (but not agriculture, the public sector, education or health services). For more details on the calculation of the APW and AWW, see OECD (2005).

$$(1 - q(S)) \equiv \left( \frac{c}{W}(S) \frac{d}{H} \right).$$

During a fraction  $q(S)$  of her active life, a female member of the labour force will be employed with probability  $p(S)$ , unemployed with probability  $(1 - p(S))$ . For this fraction of her active life, expected earnings are defined exactly as above.

During a fraction  $(1 - q(S))$  of her active life, a female member of the labour force can, legally, be on maternity leave. During this period, she can be either employed (with probability  $p(S)$ ) or unemployed. If employed, we assume that a woman will actually take leave of the maximum allowed length. In this period, she will receive a fraction  $\gamma$  of her previous earning, plus other benefits related to child care and typically independent of personal income and depending instead on average income. This second component will be denoted as  $\delta[f(S_0) - T(f(S_0))]$ . If unemployed, obviously, she will not take maternity leave. Her income will be determined by the usual unemployment benefits,  $a[f(S) - T(f(S))] + b[f(S_0) - T(f(S_0))]$ , plus the maternity-related benefits (which are, however, independent of employment)  $\delta[f(S_0) - T(f(S_0))]$ . Hence, we have:

$$\begin{aligned} I_w(S) \equiv & \int_S^U \{ q(t) [ p(t)(f(t) - T(f(t))) + \\ & + (1 - p(t))(a(f(t) - T(f(t))) + b(f(S_0) - T(f(S_0)))) ] + \\ & + (1 - q(t)) [ p(t)(\gamma(f(t) - T(f(t))) + \delta(f(S_0) - T(f(S_0)))) + \\ & + (1 - p(t))(a(f(t) - T(f(t))) + b(f(S_0) - T(f(S_0)))) + \\ & + \delta(f(S_0) - T(f(S_0))) ] \} A_t e^{-rt} dt \end{aligned}$$

As above, the rate of return on education is the value of  $r$  such that  $S_0$  is the optimal solution to the problem maximise  $V_w(S)$ .

Using the notation introduced above, setting  $q_0 = q(S_0)$ ,  $\xi = \frac{\partial q(S)}{\partial S} \Big|_{S_0}$ , and  $q_0$

$$k_0 = p_0(q_0 + (1 - q_0)\gamma) + (1 - p_0)(a + b) + (1 - q_0)\delta,$$

from  $\frac{\partial V_w(S)}{\partial S} \Big|_{S_0} = 0$ , we obtain

$$\frac{R_W}{1 - e^{-R_W H_W}} = \quad (2)$$

$$\frac{\theta \left[ \frac{1-T'}{1-\tau_0} \right] \left[ \frac{p_0(q_0 + (1-q_0)\gamma) + (1-p_0)a}{k_0} \right] + \varepsilon \left[ \frac{(q_0 + (1-q_0)\gamma - (a+b))p_0}{k_0} \right] + \xi \left[ \frac{(p_0(1-\gamma) - \delta)q_0}{k_0} \right]}{\left[ 1 - \frac{1-\tau_s}{1-\tau_0} \frac{\eta p_0(1-\phi)}{k_0} \right] + \left[ \frac{1.5\mu_s}{k_0} \frac{1}{1-\tau_0} \right]}$$

For the derivation of eq. (2), see Appendix A. Clearly, when  $q(S_0) = 1$ , (2) reduces to (1).

Equations (1) and (2) may be given a very similar interpretation: In both equations, the denominator can be seen as the sum of the marginal opportunity and direct costs of education, expressed as a share of the after-tax instantaneous earnings at  $S_0$ ,  $(f(S_0) - T(f(S_0)))$ .

Similarly, the numerator gives the marginal effect of education on earnings, once again expressed as a fraction of the after-tax instantaneous earnings at  $S_0$ . In (1), this effect can be decomposed into two components: one related to the Mincerian parameter  $\theta$  and a second one related to the effect of  $S$  on the probability of employment. In the case of women, there is a third component, due to the effect of education on fertility, captured by the parameter  $\xi$ . The 'weight' of  $\xi$  can be interpreted as the marginal increase of income (as a share of expected after-tax earnings) due to the change of the fertility rate induced by an increase in the level of education. The 'weight' of  $\varepsilon$  measures the marginal (percentage) effect of the increase in education on income due to the change in the probability of employment. Similarly, the 'weight' of  $\theta$  measures the effect on after-tax incomes due to the effects that an increase in education has on the earning function  $f(S)$ .

Regarding the  $\theta$ 's weight, a relevant role is played by the tax system: the more pro-

gressive the tax system, the lower the value of  $\frac{1-T'}{1-\tau_0}$ , and the lower the impact of

$\theta$  on the rates of return. The second term in square brackets, is a (normalised) measure of the contribution on private returns of the *net* Mincerian coefficient and it depends on the probability of being employed and on the unemployment benefit related to the previous individual wage when unemployed: the higher the probability of being employed, the higher the term in square brackets (given that  $a < 1$ ); also, the higher  $a$ , the higher the weight.

In eq. (2), the interpretation is basically the same. Here, the weight also depends on the benefit  $\gamma$  that a woman obtains if she is out of work because she is on maternity leave.

The most instructive way to look at the second component of the numerator, i.e.  $\varepsilon$  and its weight, is as the product of the derivative of being employed ( $\varepsilon \times p_0$ ) weighted by the *net* income gain of being employed. We can interpret the last term in brackets, in a similar way, once we take into account that

$$\xi = \frac{\partial q(S)}{\partial S} \Big|_{s_0} \cdot q_0$$

### 3 Estimation of the Mincerian coefficients

The main ingredient for evaluating the returns on education is the estimation of the effect of education on the wage profile. The standard approach has been developed building on Mincer (1974). There is a huge literature on Mincerian wage equation. For an overview of single- and multi-country studies and stylised facts, see Peracchi (2006), Budria and Pereira (2005), Psacharopoulos and Patrinos (2004), Martins and Pereira (2004), Harmon, Walker and Westergaard-Nielsen (2001), Harmon, Oosterbeek and Walker (2003), Card (1999).

In a multi-country analysis, the most relevant difficulty is the comparability of the data. We provide a direct estimate of the Mincerian coefficients for 12 West European countries using a large European micro-dataset, the EU-SILC data for the year 2007 (revision 2).<sup>5</sup> The dataset is a voluntary survey of households coordinated by Eurostat. The sampling procedure is based “on a nationally representative probability sample of the population residing in private households”.<sup>6</sup> Starting in 2004, the EU-SILC data have been collected annually by the national statistical offices for the purpose of providing comparable information<sup>7</sup> on income and the poverty situation in EU member countries. In most of the countries, the data are gathered using surveys only, whereas in some countries additional information is drawn from administrative sources. EU-SILC data have replaced the European Community Household Panel (ECHP) used in a large number of studies (Prieto-Rodriguez, Barros and Vieira (2008), Middendorf (2008), Heinrich and Hildebrand (2005)). Most of the multi-country studies on education combined ECHP data with other sources. For instance, considering two recent papers, Strauss and de la Maisonnette (2009), limiting the analysis to tertiary education, emphasise differences in the wage premium in 21 OECD countries combining data taken from six different panel data studies.

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<sup>5</sup> The second revision of the data for the year 2007 was available in 2010. Possibly, during 2011, there will be a third revision of the same dataset. To check the sensitivity of the data, we have run the regressions for the 12 European countries with both the first and second revision of the data for 2007. The Mincerian coefficients do not change.

<sup>6</sup> See European Commission/Eurostat (2007), EU-SILC User Database Description, version 2007, p. 22. available at <http://circa.europa.eu/Public/irc/dsis/eusilc/library>.

<sup>7</sup> The same questionnaire is used in all the countries included in the survey.

Brunello, Fort and Weber (2009), pooling data from three different sources, study the effect of quantity of education on wage distribution in 12 European countries.

Compared to other datasets, the EU-SILC provides the opportunity to use very recent and most comparable micro-data to estimate the cross-country difference in returns on education.<sup>8</sup> To the best of our knowledge, only two papers have used the EU-SILC dataset to analyse the returns to education in Europe. Biagetti and Scicchitano (2009) use the 2007 dataset, considering only the male population in eight countries. They apply a quantile regression estimation to analyse the link between education and wage inequality. Davia, McGuinness and O’Connell (2009) use the EU-SILC data 2005-2006 for seven European countries to explain cross-country differences in the rates of return in terms of variations in ‘relative risk’. They estimate the Mincerian coefficients for different ISCED levels by gender, also accounting for selection bias (for the female population). Their main conclusion is that “risk explains variation of rate of returns in particular at ISCED 5 level”.

The EU-SILC data contain cross-sectional information about households’ financial behaviour and fundamental individual socio-demographic characteristics such as age, gender, highest completed degree, parents’ backgrounds, family composition, working status, etc. On the basis of the availability and comparability of the data, we have selected 12 countries with different welfare regimes and institutions. We restrict the sample to men and women aged 25-64, for whom information about their earnings is available.

A methodological problem arises when estimating the schooling coefficients due to the possibility of non-random selection of the sample from the workforce (Heckman (1979, 1980), Hoffmann and Kassouf (2005)). A priori, we can assume that the relevance of this problem varies across genders. Hence, given the aim of our study, it is particularly important to take into account this possible bias. We estimate the wage equation using the selection model by Heckman to control for potential selection bias into employment.

Given a sample of individuals, denoted by the subscript  $i$ , observed at time  $t$ , we proceed to estimate the econometric model (outcome equation)

$$\log w_i(\cdot) = \beta_0 + \theta S_i + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 For_i + \beta_4 Mar_i + \beta_5 PS_i + \beta_6 PT_i + \beta_7 \hat{\lambda}_i + u_i$$

where  $w_i$  is a measure of earnings for individual  $i$ ,  $S_i$  is a measure of his/her schooling while  $x_i$  measures work experience. Experience is included as a quadratic term to capture the concavity of the earning profile. We also include several dummy variables to control for nationality, marital status, public sector and part-time

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<sup>8</sup> For a discussion on the quality of the data, see Schneider and Muller (2009).

job. As usual,  $\hat{\lambda}_i$  is the inverse Mills ratio, estimated from the first stage, and  $u_i$  is a disturbance term representing other explanatory variables. The Heckman selection equation is as follows:

$$z_i(\cdot) = \alpha_0 + \alpha_1 S_i + \alpha_2 x_i + \alpha_3 x_i^2 + \alpha_4 For_i + \alpha_5 Mar_i + \alpha_6 YCh_i + \alpha_7 OCh_i + \alpha_8 FInc_i + e_i$$

where  $YCh_i$  is the number of young children, aged 0-5, while  $OCh_i$  is the number of older children, aged 6-17, in the household.  $FInc_i$  is a measure of the income of the other members of the family. In our case it is the total household income minus own labour income. Finally,  $e_i$  is a zero mean error term.<sup>9</sup>

The schooling coefficient  $\theta$  in the wage equation can be interpreted as the wage premium. This coefficient is then used as an input in the computation of the internal rate of return of investment in education, i.e. to calibrate the model.

There are additional problems related to the data used in the estimation, in particular, the measures of earning, schooling and experience. Before moving to the detailed presentation of our estimates, let us discuss these issues. In the EU-SILC data, gross wages are reported on an annual basis for most of the countries and as gross monthly earnings for Italy and Portugal. We use the information available to compute the log of hourly wages, the dependent variable in our wage regressions.

With regard to the educational background of respondents, the highest ISCED level attained is reported, as well as the year when it was attained. Combining these variables, we derive the standard measure of schooling attainment, the number of years of education.<sup>10</sup>

To measure the work experience we used the actual experience,<sup>11</sup> available for most of the countries.<sup>12</sup> In the following table, we report only the estimated values of the coefficients of schooling and of  $\lambda$ . Estimates of the coefficient of other explanatory variables are available upon request.

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<sup>9</sup> The two errors terms,  $e_i$  and  $u_i$ , are jointly (bivariate) normally distributed.

<sup>10</sup> For Denmark and Sweden, the year when the highest level was attained is not available. For these two countries, we compute the average number of years needed to attain each ISCED level, considering the typical graduation ages (OECD, Education at a Glance 2009) minus six.

<sup>11</sup> This is reported by respondents as “number of years spent in paid employment”.

<sup>12</sup> Again, this does not apply to Denmark and Sweden. For them, we computed the potential experience as the age of the individual, minus the years of education, plus six.

**Table 1: Mincerian coefficients, by gender**

Country	Male			Gender		
	$\theta_M$	$\lambda_M$	$N_M$	$\theta_W$	$\lambda_W$	$N_W$
Austria	0.0495*** (0.0283)	-0.7837*** (0.0348)	2,953	0.0614*** (0.0037)	0.2394*** (0.0382)	3,384
Belgium	0.0443*** (0.0024)	0.1083*** (0.0269)	2,790	0.0531*** (0.0033)	0.0970** (0.0478)	3,415
Denmark	0.0446*** (0.0026)	0.1064*** (0.0285)	2,998	0.0508*** (0.0025)	-0.0035 (0.0345)	2,918
France	0.0462*** (0.0021)	0.0520** (0.0316)	4,490	0.0484*** (0.0023)	0.0872*** (0.0282)	5,214
Germany	0.0461*** (0.0017)	0.0180 (0.0232)	5,596	0.0449*** (0.0022)	0.0618** (0.0311)	7,081
Ireland	0.0569*** (0.0036)	0.1993*** (0.0647)	2,305	0.0859*** (0.0042)	0.4167* (0.3170)	3,312
Italy	0.0363*** (0.0010)	0.0633*** (0.0179)	10,724	0.0406*** (0.0015)	0.1426*** (0.0234)	12,798
Luxembourg	0.0827*** (0.0022)	0.1061** (0.0464)	2,034	0.0842*** (0.0037)	0.2216*** (0.0570)	2,409
Netherlands	0.0404*** (0.0021)	0.0288 (0.0464)	5,467	0.0286*** (0.0028)	-0.0466*** (0.0438)	6,130
Portugal	0.0727*** (0.0034)	0.4410*** (0.0340)	2,179	0.0940*** (0.0033)	0.4920*** (0.0275)	2,683
Spain	0.0577*** (0.0022)	0.2067*** (0.0322)	6,610	0.0705*** (0.0039)	0.2231*** (0.0417)	8,743
Sweden	0.0543*** (0.0038)	0.0308 (0.0392)	3,882	0.0342*** (0.0042)	-0.3555*** (0.0417)	3,816

Standard errors in parentheses.

\*significant at 10%; \*\*significant at 5%;\*\*\*significant at 1%.

In line with the previous literature, the values of  $\theta_W$  are equal to or larger than those of  $\theta_M$ . Relevant (and positive) differences are observed in Ireland, Portugal and Spain. The only countries where  $\theta_W$  is lower than  $\theta_M$  are Sweden, the Netherlands and Germany, where the difference is not relevant.

In Sweden, the public sector is a very relevant component of GDP and there is higher percentage of skilled women, compared to skilled men, working in this sector. Also, our estimates show that the wage level is typically lower in the public sector. Therefore, differences by gender of the skill composition of workers in public employment can explain the gender gap in the schooling coefficients.

The female job market in the Netherlands is characterised by a high proportion of women in the labour force working part-time. This proportion is even higher among low-skilled women and working mothers. Our estimation strategy does not allow us to fully capture the impact of part-time jobs by skill levels. In a separate regression, not reported in the text, we combine educational levels (ISCED levels) and part-time



experience. The values of the coefficients are decreasing for education. This suggests that the high incidence of part-time jobs may play a role in explaining the lower rates of return for females as compared to the male population.

For Germany, our estimation is in line with the results in the literature (Gebel and Pfeiffer (2010)). In this country, the occupational segregation by gender, in particular in the low-wage sectors, is a well-known and widely discussed phenomenon. As pointed out by Achatz et al. (2005), only one third of the gender gap in Germany can be explained by differences in human capital. It seems to be more important that wages in female-dominated job cells are typically lower than in male-dominated cells, where a job cell consists of a worker in the same occupation within the same firm. (Basically, this concept allows them to purge the results of unobserved heterogeneity due to firm-specific factors.) The findings of Achatz et al. can be taken as evidence of the importance of the sorting of females into female-specific jobs and, thus, gender-specific occupational segregation. Segregation makes it difficult for highly skilled women to obtain jobs in the upper part of the occupational hierarchy (see also Achatz (2008)). Moreover, there is evidence that, if they do obtain such jobs, they no longer suffer wage discrimination (Bush and Holst (2011)), but that the 'glass ceiling' effect makes it hard to secure these jobs. Clearly, this phenomenon has an impact on the Mincerian coefficient of the female population.

## 4 Calibration of the model and main results

In this section, we present our estimates, by gender, of the private returns on education. They are computed calibrating equations (1) and (2) above, using macro-data. The only exception is for the schooling coefficients, where we use our estimations of the Mincerian coefficients.

For each country, we consider a representative married couple with two children. de la Fuente (2003) takes, instead, a single individual with a wage equal to 100% of the APW. We do not refer to single parents because, in most of the countries considered, most women are married at the time of child-bearing. We assume that male earnings are equal to 100% of AWW, while female earnings are 67% of AWW. This is a fairly realistic assumption, if we take into account the actual average earnings in manufacturing for women and men in the European countries (OECD (2009)).

We assume that, after schooling, agents are in the labour force until the average age of retirement. We also assume that they want to work 20% of a standard work year while studying. The computations also consider taxes on labour income and unemployment benefits. In particular, for women, we include general government child cash benefits (but not tax expenditures, i.e. tax allowances or tax credits) and benefits related to maternity and childcare provided to working women. In the sequel, when convenient, we will use the subscripts  $W$  and  $M$  to denote the values of the parameters for women and men, respectively.

To compute the expected length of working life,  $H_M$  and  $H_W$ , we subtract the maximum value between the country average years of schooling plus six and 15 (the minimum age to legally enter the labour market) from the average ages of retirement,  $U_M$  and  $U_W$ . Data are taken from the Eurostat LFS database and refers to 2007 for all the countries but Ireland (2006) and Luxembourg (2003).

One of the motivations for the study of private returns by gender is a result of the large differences in the gender-specific rates of unemployment. As we have seen, rates of unemployment enter equations (1) and (2) because they help determine the weights of  $\theta, \varepsilon$  and  $\xi$ . Therefore, significant differences in the rate of unemployment by gender and by country could determine differences in the rates of return. Indeed, in most of the countries, female rates of unemployment are higher. The negative relationship between unemployment and level of education – or positive relationship between employment and level of education – is widely studied in the economic literature. Our data confirm that, independently of gender, an increase in the level of education has a positive effect on the probability of employment.

To allow for an easier comparison of the results, in equations (1) and (2), the effect of education on the probability of employment is measured by  $\varepsilon \equiv \frac{p'}{p_0}$ , where  $p(S) \equiv (1 - u(S))$  and  $u(S)$  is the rate of unemployment for individuals with a level of education  $S$ . The Eurostat LFS database provides the gender-specific rates of unemployment in 2007 for three different levels of education. It is then possible to approximate the average increase in probability of employment,  $p'(S_0)$ . First, we consider the marginal increment of the probability for each level of education divided by the cumulate years of schooling associated with the attainment levels  $S_{(n)}$  (see de la Fuente and Doménech (2006)), using the following equation for  $n = 1, 2$ :

$$c_{(n)} = \frac{P_{(n+1)} - P_{(n)}}{S_{(n+1)} - S_{(n)}}$$

where 1 denotes below upper secondary education, 2 upper secondary education and 3 tertiary education. Then, we compute  $p'(S)$  as the weighted average of the two increments with weights of 2/3 for  $c_{(1)}$  and 1/3 for  $c_{(2)}$ . Finally,  $\varepsilon$  is obtained as

$\frac{2}{3} \frac{p'(S)}{p(S)}$ . The correction factor, 2/3, is used to capture the fact that the probability of employment depends on many other factors other than education.

During the years of schooling, the probability of being employed is, in general, lower. To capture this effect, we correct the probability of being employed while in school using a factor that we denote  $\eta_M$  for males and  $\eta_W$  for females. We compute these

factors using the unemployment rates, by gender, of the young population in education and not in education. We assume that, while in school, individuals devote a fixed fraction  $\phi$ ,  $\phi = 0.8$ , of their time to studying. The data are taken from Education at a Glance (OECD (2009)) and refer to 2007.

The tax system is extremely important and it affects the private returns on education in many different ways. Given the focus of our analysis and the basic features of the family structure in the European countries considered, we introduce two different types of tax payers in the analysis. We assume that, while in school, individuals are taxed as single (OECD (2009)). After school, they are taxed as members of a family consisting of two working parents and two children. Indeed, in most countries, marginal tax rates,  $T'$ , are different for the two types of tax payers. In all the countries, the average income tax rates,  $\tau_0$ , are lower for a family with two children than for a single person. The data refer to 2007 (OECD (2008)<sup>13</sup>). We use this date to calculate the private returns independently of gender. (However, effective tax rates may vary across gender because the individual incomes of men and women are different, by assumption).

Concerning benefits, the analysis is more complex. In our model, we consider two different categories of benefits: the first refers to unemployment. The second is related to maternity and is, normally gender specific. Unemployment benefits are computed as the sum of two components. One captures the benefits related to previous net earnings ( $a$ ), while the second captures benefits that are assumed to be related to average net earnings ( $b$ ). The net (i.e. after-tax) replacement rates ( $a + b$ ) are different for different types of family (single person, married couple, couple with two children, single parent with two children). Also, we assume that the distribution is gender-independent. The values of ( $a$ ) and ( $b$ ) for men and women are different because of the assumption of different earnings as a percentage of AWW. The net replacement rates vary greatly across countries<sup>14</sup> and are best seen as no more than an approximation of the actual benefit systems.<sup>15</sup> The data are from the OECD (2007).

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<sup>13</sup> Bear in mind that OECD data define the marginal tax rate as the rate applied to an increase in the income of the main earner, here, by assumption, the husband. Evidently, the actual marginal tax rates on women's wages may be lower (because we are assuming that their wages are lower). This may induce an underestimation of the actual returns to education for women.

<sup>14</sup> In some countries, there are only benefits proportional to previous earning (this implies that  $b=0$ ), in other countries they are fixed ( $a=0$ ) and in still others they are mixed: some of the unemployed have a fixed subsidy, while others receive benefits related to their previous earnings (MIX,  $a \neq 0, b \neq 0$ ).

<sup>15</sup> This is confirmed for Belgium. For this country, a more detailed analysis (see de la Croix and Vanderberghe (2004)) estimates a net replacement rate of 34%, which is much lower than the 66% used in de la Fuente and 71% used here. The OECD data are, however, the best available for a comparative analysis.

The second kind of benefits is related to maternity. In this case, we must take into account the position of the individual woman in the labour market. In all the European countries, in order to reconcile women's family life and work, the law establishes the right for a working woman to leave her job for a period of time for maternity and child care. A fraction of this period is paid (by the firms or by the public insurance system; this difference is irrelevant to the aim of this study). We consider the amounts of money that women receive during this time (i.e. maternity, childcare and parental leave due to maternity) as a 'benefit',  $\gamma$ , that they can obtain if they work and have a child (OECD (2007)). Moreover, for all women who have a child, independently of their position in the labour market, the government normally pays cash benefits,  $\delta$ . The child benefit programmes also differ dramatically in the 12 countries (OECD (2007), MISSOC (2007), ISSA (2006-2007)). These policies may have a relevant impact on the labour market. In general, it is shown that the first kind of benefits tend to increase the participation rate for women, while the second has a negative effect on it because it increases the opportunity cost of work and, therefore, the reservation wage of women. All our calculations related to both kinds of benefits are available upon request.

As explained above, the negative relationship between fertility rates and education is an important component of our analysis. The existence of a negative relationship is confirmed for most countries, with average fertility rates of 1.50%, 1.23% and 1.08%, respectively, for low, medium and high levels of education. To evaluate if and how this affects the private returns on education of women, we introduce a new variable  $q(S)$ , defined as the fraction of the (full-time) working life when the representative woman does not have maternity leave. Then,  $(1 - q(S))$  is the fraction of her active life which can be spent on maternity leave (we can think of this as the time immediately before and after the birth of her children). This variable,  $q(S)$ , is an increasing function of  $S$  and equal to:

$$q(S) = \left( 1 - \frac{c}{W}(S) \frac{d}{H} \right)$$

where the fertility rate  $\frac{c}{W}(S)$  ( $c$  is the number of children,  $W$  is the number of women in fertility age) is a decreasing function of schooling. We multiply the average number of children per woman by the fraction of the working life a woman can spend caring (full time) for each child,  $\frac{d}{H}$ , to measure the time women spend off work on average in each country for maternity-related reasons. The data used to compute the length of maternity leave, measured in years, for each country are taken from OECD (2007).

The marginal effect of education on fertility is captured by the parameter  $\xi = \frac{q'}{q_0}$ .

To estimate this, we use the same methodology adopted to estimate the sensitivity of the probability of employment. As mentioned above, the EU-SILC data do not provide information to compute the fertility rates directly. The most recent and comparable data we have found to calculate them are in UNCE (different years) and refer to women aged 20-49 (for some countries, the age groups are different). For Denmark, these data are unavailable and so we use a different source which provides fertility rates by education in 1979 (Jones (1982)). Considering the European countries for which fertility rates by education are available from both sources (Finland, France, Italy and Spain), one can see that they have decreased by about 33% over the last two decades. To take into account the general tendency of fertility rates to decrease during this period, we multiply the value of 1979 by 2/3 in order to correct the original estimates. In Table 2, we present the fertility rates by levels of education, maternity leave and childcare benefits.

**Table 2: Fertility rates by education levels,  $d$ ,  $\gamma$  and  $\delta$**

Country	Fertility rates, by education			Leave period <sup>b</sup>	Mat. leave benefits <sup>c</sup>	Child care benefits
	Low	Medium	High	$d$	$\gamma$ %	$\delta$ %
Austria	1.10	1.10	1.10	2.15	29	16
Belgium	1.39	1.08	1.09	0.52	51	16
Denmark <sup>a</sup>	1.47	1.47	1.24	0.96	100	11
France	1.88	1.38	1.10	3.06	30	7
Germany	1.25	1.05	1.07	3.12	30	21
Ireland <sup>a</sup>	1.48	1.43	1.18	0.92	38	18
Italy	1.52	1.07	0.88	0.90	51	0
Luxembourg	1.39	1.08	1.09	0.77	70	40
Netherlands	1.38	1.17	0.76	0.31	100	7
Portugal	1.71	1.07	1.11	0.33	100	0
Spain	1.65	1.16	1.00	3.12	10	0
Sweden	1.80	1.46	1.26	1.62	74	12

Source: UNCE, a. Jones (1982)

b. Total leave in years (maternity, parental, childcare).

c. Maternity leave benefits as a % of women's earnings, 67% of the AWW.

As standard in the literature, we define the direct private costs of schooling  $\mu_s$  as a fraction of AWW gross earnings. It is computed as the weighted average of secondary and tertiary levels by 2/3 and 1/3 respectively. The costs are net costs of direct public subsidies to students and, therefore,  $\mu_s$  can have a negative value when these subsidies exceed tuition and other direct costs. For men, we use the data from

OECD (2009).<sup>16</sup> For women, given that female average earnings are estimated at 67% of the AWW, the parameter defining direct private costs of education as a fraction of the female earning is  $1.5\mu_s$ , so that the actual monetary costs are the same. Further explanations of the data and of the details of the computations are available upon request.

On the basis of the above, we are able to explicitly compute (numerically) the values  $r_W$  and  $r_M$ , using the estimates described to compute the right-hand side of equations (1) and (2). Table 3 reports the private rates of return on education by gender for 12 West European countries and the numerical values of the main components of the numerators and denominators of equations (1) and (2). For most (to be precise, 9 out of 12) of the countries,  $r_W$  is larger than  $r_M$ . Let us first focus on men. For them, private returns range, for most countries, between 4% and 6%, with an average of 5.7%. The minimum value, 3.9%, is in Italy, while the maximum is 8.6% in Luxembourg. To interpret the table, see eq. (1) in Section 2, where the numerator represents the marginal gain due to an increase in schooling, while the denominator measures the marginal net costs.

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<sup>16</sup> Values for tertiary expenditure are missing for Denmark and Luxembourg. For these countries, following a common procedure, the values from Sweden and Belgium are assigned, respectively.

**Table 3: Returns to education, by components**

Country	Austria	Belgium	Denmark	France	Germany	Ireland
<i>Male</i>						
Minc comp	0.03716	0.03096	0.04074	0.04183	0.03841	0.04618
Empl comp	0.00089	0.00150	0.00020	0.00084	0.00133	0.00107
Opp cost	0.78216	0.77095	0.78752	0.81402	0.79648	0.78951
Direct cost	0.07455	0.00098	-0.02673	0.01880	0.04239	0.01703
$r_M$ %	5.00	4.64	6.10	5.75	5.32	6.81
<i>Female</i>						
Minc comp	0.04550	0.03599	0.04553	0.04347	0.03659	0.06903
Empl comp	0.00035	0.00126	0.00011	0.00029	0.00015	0.00046
Fert. comp	0	0.00009	-0.00003	0.00264	0.00055	0.00014
Opp cost	0.77071	0.77806	0.79112	0.79990	0.78070	0.78351
Direct cost	0.11613	0.00147	-0.03975	0.03040	0.06592	0.02580
$r_W$ %	5.81	5.47	6.88	6.36	4.82	9.92
Country	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden
<i>Male</i>						
Minc comp	0.02891	0.06215	0.03335	0.05902	0.04650	0.03459
Empl comp	0.00031	0.00011	0.00020	0.00006	0.00024	0.00050
Opp cost	0.78748	0.81620	0.80423	0.80629	0.79872	0.80829
Direct cost	0.01783	0.00074	0.02887	0.06939	0.05050	-0.03739
$r_M$ %	3.88	8.63	4.57	7.90	6.41	5.23
<i>Female</i>						
Minc comp	0.03234	0.06252	0.02365	0.07637	0.05678	0.02126
Empl comp	0.00040	0.00009	0.00032	0.00015	0.00015	0.00040
Fert. Comp.	0.00047	-0.00006	-0.00001	0	0.00304	0.00018
Opp cost	0.78577	0.81328	0.80692	0.81267	0.79773	0.80415
Direct cost	0.02710	0.00111	0.04331	0.10436	0.08135	-0.05619
$r_W$ %	4.48	8.68	2.72	9.67	7.97	2.76

Source: own calculations based on EU-SILC (2007)

In general, the key component of marginal costs are opportunity costs. In only three countries (Austria, Portugal and Spain), direct costs exceed 5% of instantaneous net earnings. Given that a negative value of direct costs implies government subsidies in excess of private costs, in some countries, such as Denmark and Sweden, subsidies are particularly generous. On the other hand, opportunity costs are (at the margin) always above 77% of net earnings.

Similarly, if we consider the composition of the numerator, we can say that the main component of the payoffs depends on the coefficient of the Mincerian equation, while the effects of education on the probability of employment is of a smaller order of magnitude.

Let us now consider the figures for women in particular. For most of the countries, the private returns of women lie between 6% and 7%, with an average of 6.02%.

They are much lower than the average in Sweden (2.8%) and in the Netherlands (2.7%). For Ireland, Luxembourg and Portugal, the rates are much higher than average: 9.9%, 9.7% and 8.7%, respectively.

As in the case of men, by and large, the most important component of costs are opportunity costs (even if, due to the lower net earnings, direct costs are somewhat more relevant).

Comparing the weights of the components of the numerator, we can see that the effects of  $\varepsilon$  and  $\xi$  are quite low. The most important component of the numerator is, as before, related to the coefficient of the Mincerian equation.

The effects of education on the probability of employment and fertility vary greatly across countries, also depending on the policy parameters. While it is usually smaller, the fertility effect is of the same order as the employment effect. However, we can conclude that the coefficients  $\theta$  and the associated weights, measuring the impact of taxes on labour income, drive the decision of the agents. To better understand the role of these components in determining the returns, we decompose and compare each part of the weights and their distributions (modulo a normalisation). Looking at mean values and variances across countries, not reported in the text, we conclude that while the distribution of the weights of  $\theta$  does not vary much across genders, the distribution of the weights of  $\varepsilon$  is quite different, with a lower mean and higher variance for the female population, due to the large differences in the public policies related to unemployment benefits and maternity leave benefits.

## 5 Elasticities

The maternity-related policy parameters ( $\gamma$  and  $\delta$ ) vary across countries. Therefore, it is natural to ask what the effect of changes in these is on female rates of returns. Increases in the values of  $\gamma$  and  $\delta$  have a *direct effect* on the rate of return  $R$  because they decrease the opportunity cost of maternity. There is also an *indirect effect* because changes in  $\gamma$  and  $\delta$  affect the fertility rate and may influence the values of  $q(S_0)$  and  $p(S_0)$ . Here, we will only consider the (presumably larger) *direct effects*. The indirect effects depend, among other parameters, on the second derivatives of  $q(S)$  and  $p(S)$ . Unfortunately, the available data do not allow for any reasonable conjecture on their values.

To compute the effects of changes in  $(\gamma, \delta)$  on  $R_w$ , rewrite eq. (2) as  $F(R_w) - G(\gamma, \delta) = 0$ . Then, by the implicit function theorem,

$$\frac{\partial R_w}{\partial \gamma} = -\frac{\frac{\partial G(.)}{\partial \gamma}}{\frac{\partial F(R_w)}{\partial R_w}} \quad \text{and} \quad \frac{\partial R_w}{\partial \delta} = -\frac{\frac{\partial G(.)}{\partial \delta}}{\frac{\partial F(R_w)}{\partial R_w}}.$$



We must bear in mind that the two derivatives measure the rates of change of  $R_w$  due to changes in  $\gamma$  and  $\delta$ , under the assumption that the optimal level of schooling is invariant, because, by construction, in this model, the optimal value of  $S$  is given (and equal to the country average level) while the rate of discount is treated as an endogenous variable. Also, we abstract from the possible effects on equilibrium wages. Therefore, these elasticities must be interpreted simply as a measure of the relevance of these policy parameters in determining  $r_M$  and  $r_W$ .

Both derivatives have an undefined sign. For the second one, if  $q'$  is positive (or negative but sufficiently small), the sign is negative, as one would expect, because increases in  $\delta$  in turn increase the opportunity cost of schooling and, since  $S_0$  is given (individuals cannot change the level of education chosen), the rate of return decreases, in order to guarantee that  $S_0$  persists as the optimal choice for the individual. In the sequel, while discussing our estimates, we will see that, for the sample of countries considered here, the estimated values of  $\frac{\partial R_w}{\partial \delta}$  are, indeed, always negative.

It turns out that the first derivative is also always negative. This is somewhat counterintuitive because an increase in the value of  $\gamma$  increases the expected future income. However, it also increases the opportunity costs of schooling. The impact of a change in  $\gamma$  on the opportunity costs dominates all the others. Numerically, in most of the countries, the values of  $q'$  and of  $\varepsilon$  are fairly small. This is also possibly due to the postulated time independence of the variables.

Following the same approach, we estimate the elasticities of  $R_M$  and  $R_W$  with respect to the unemployment benefit parameters, marginal and average tax rates. Direct computation of the elasticities, by gender, is reported in Appendices B.1 and B.2. The numerical values are presented in Table 4.

**Table 4: Elasticities of PRR**

Country	Unemployment benefits		Marginal tax rate		Average tax rate		Maternity leave	Child care
	Male	Female	Male	Female	Male	Female	$\gamma^c$	$\delta^c$
Austria	-0.68	-0.61	-5.93	-6.34	1.96	-5.54	-0.01	-0.09
Belgium	-1.07 <sup>a</sup>	-1.24 <sup>a</sup>	-7.33	-7.91	2.68	3.34	-0.03	-0.03
Denmark	-0.31 <sup>a</sup>	-0.51 <sup>a</sup>	-5.42	-5.88	5.08	10.01	-0.12	-0.05
France	-0.64	-0.62	-3.07	-3.15	1.99	0.19	-0.24	-0.13
Germany	-1.91	-2.13	-5.33	-5.22	2.30	-3.80	-0.05	-0.20 <sup>b</sup>
Ireland	-0.63 <sup>a</sup>	-0.92 <sup>a</sup>	-2.78	-5.98	0.00	0.93	-0.07	-0.16
Italy	-0.35	-0.33	-3.96	-3.95	0.92	-0.22	-0.10	-
Luxembourg	-0.28	-0.28	-6.20	-6.16	2.66	2.01	-0.09	-0.18
Netherlands	-0.21	-0.31	-5.01	-5.01	3.65	-3.70	-0.07	-0.01
Portugal	-0.23	-0.18	-5.54	-9.18	1.64	-1.95	-0.09	-
Spain	-0.33	-0.28	-3.68	-4.80	0.68	-1.08	-0.07	-
Sweden	-0.32 <sup>a</sup>	-0.11 <sup>a</sup>	-6.98	-6.65	2.72	9.84	-0.32	-0.11

<sup>a</sup> Replacement rates are based on the average earning of the country.

<sup>b</sup> For Germany: Kindergeld.

<sup>c</sup> The elasticities with regard to  $\gamma$  and  $\delta$  are computed for the female population.

The first two columns report the elasticities of the returns on education for men and women with respect to the replacement rates. An exogenous increase in unemployment benefits has a negative impact on the returns on education of both genders. The magnitude of this effects is, however, fairly small. What is much more significant is the impact of a change in the tax system, described in the model by the marginal and average tax rates. According to the theoretical model, (see Appendix B), the sign of the elasticity with respect to the marginal tax rate is negative for both genders. The numerical values estimated for all the countries satisfy this prediction. On the other hand, our model does not deliver a sign restriction for the elasticities with respect to the average tax rate. This is because, as usual with this approach, we are taking as given the relevant marginal tax rate (see the details of the model in Appendices A and B). Hence, an increase in the average tax rate can be interpreted as a decrease in the progressivity of the tax system. This implies that the sign of the elasticity can vary according to the position of the individual in the wage distribution. According to our results, for men the impact of an exogenous increase in the average tax rate is always positive. For women, the sign changes considerably across countries. It may be positive or negative. It is positive and significant in countries where the tax system is more progressive and the relative earnings distributions of females is fairly close to that for men, such as in Denmark and Sweden.

## 6 Conclusion

Our aim was to compare the returns on education of men and women and to analyse the role and the impact of Mincerian coefficients in the decision of the individual to invest in education. To this aim, we have embedded the Mincerian coefficients in the individual decision problem, together with several other parameters capturing the main characteristic of the labour market and tax system, the costs of the investment in education, and public policies which also affect the private incentive to invest in education and, therefore, the rate of returns. To compute the gender-specific returns, we have also explicitly considered several policy variables related to maternity episodes.

Our results confirm that education is an important determinant of individual earnings for both genders. Private returns on education of females are higher than those of males in all the countries in the sample but Germany, the Netherlands and Sweden. The gender gap in the returns can be explained mainly by the Mincerian coefficients, typically larger for women, which more than compensate the negative effects on women's rates of return triggered by higher unemployment rates and maternity-related benefits (always lower than a full wage).

Finally, we have estimated the effects on the rates of returns of some policy parameters. In this regard, we can conclude that, for both genders, an increase in unemployment benefits always has a negative impact on the rates of return to education. Concerning the tax system, an increase in the marginal tax rates always has a negative impact on rates of return to education, while an increase in the average tax rates can have a negative or positive impact on rates of return to education, according to the progressivity of the tax system. To understand the effect of both kinds of child benefits on the private returns, we have numerically computed the elasticities of  $R_w$  with respect to  $\gamma$  and  $\delta$ , for the 12 countries. In each country, the elasticities are negative and not high. Hence, an exogenous increase in  $\delta$  and  $\gamma$  always implies a weak decrease in women's private returns. While usually smaller, the fertility effect is of the same order as the employment effect. However, our results strongly suggest that the Mincerian coefficients,  $\theta$ , and changes in labour income taxes drive the rates of return of both men and women, while other components are of a smaller order of magnitude.

As explained above, our estimates are best seen as an upper boundary for the actual values of the returns. This is for several reasons, related both to the structure of the model and to the values of the parameters used in the analysis. With respect to the second issue, we have used the OECD (1999) estimates of the replacement rates for unemployed individuals. However, independent estimates for Belgium (de la Croix and Vanderberghe (2004)) suggest that, at least for this country, actual replacement rates are substantially lower. Given that unemployment rates for women are higher, overestimates of replacement rates would have a larger effect on the

values of  $r_W$  than on those of  $r_M$ . Given the structure of the model, in our estimates, we ignore the time-dependence of maternity and unemployment benefits, which probably induces an overestimate for women. We compute only for women the share of maternity benefits which are not employment related (measured above by  $\delta$ ). Given that these benefits are provided to families and not just to female members of the labour force, the way we have treated them could have caused some additional overestimate of female returns as compared to male returns.

Furthermore, as in de la Fuente (2003), we have considered expected lifetime returns. Given that women's rates of unemployment are higher than those of men, female incomes are probably more variable over time. This has no effect on our estimate of  $R$ , but could have effects on the actual well-being of risk-averse individuals. Unemployment and maternity-related benefits smooth income over the lifetime and, of course, their relevance for the individual utility increases with the degree of risk aversion. However, the differences in the orders of magnitude of the factors affecting the rates of return on education are such that we do not believe that a main qualitative conclusion will be affected by introducing an empirical plausible degree of risk aversion.

## Appendix A: Derivation of equations (1) and (2)

For convenience, in this Appendix, we will omit the subscript  $W$ .

The point of departure is given by the first order condition of the optimisation problem of the representative female agent:

$$\frac{\partial V(S)}{\partial S} \Big|_{s_0} = \frac{\partial I(S)}{\partial S} \Big|_{s_0} - \frac{\partial C(S)}{\partial S} \Big|_{s_0} + \frac{\partial J(S)}{\partial S} \Big|_{s_0} = 0. \quad (\text{A.1})$$

Define

$$k(S) \equiv q(S) \left\{ \begin{array}{l} p(S) [f(S) - T(f(S))] + \\ (1-p(S)) [a(f(S) - T(f(S))) + \\ b(f(S_0) - T(f(S_0)))] \end{array} \right\} +$$

$$(1-q(S)) \left\{ \begin{array}{l} p(S) \left[ \begin{array}{l} \gamma(f(S) - T(f(S))) + \\ \delta(f(S_0) - T(f(S_0))) \end{array} \right] \\ + (1-p(S)) \left[ \begin{array}{l} a(f(S) - T(f(S))) + \\ b(f(S_0) - T(f(S_0))) + \\ \delta(f(S_0) - T(f(S_0))) \end{array} \right] \end{array} \right\}.$$

Then,

$$\frac{\partial I(S)}{\partial S} \Big|_{s_0} = -[k(S_0)A_0e^{-RS_0}] + \frac{\partial k(S)}{\partial S} \Big|_{s_0} A_0 \frac{[e^{-RU} - e^{-RS_0}]}{-R}$$

where, setting  $q_0 = q(S_0)$  and  $q' \equiv \frac{\partial q(S)}{\partial S} \Big|_{s_0}$ ,

$$\frac{\partial k(S)}{\partial S} \Big|_{s_0} = q' \left\{ \begin{array}{l} [(p_0 + (1-p_0)(a+b)] - \\ [p_0(\gamma + \delta) + (1-p_0)(a+b + \delta)] \end{array} \right\} (f(S_0) - T(f(S_0))) +$$

$$p' \left\{ \begin{array}{l} q_0[1 - (a+b)] + \\ (1-q_0)[(\gamma + \delta) - (a+b + \delta)] \end{array} \right\} (f(S_0) - T(f(S_0))) +$$

$$q_0(p_0 + (1-p_0)a) (f'(S_0) - T'(f(S_0))f''(S_0))$$

Moreover,

$$\frac{\partial J(S)}{\partial S} \Big|_{s_0} = [\eta p_0 [(1-\phi)f(S_0) - T((1-\phi)f(S_0))] A_0 e^{-RS_0}]$$

and

$$\frac{\partial C(S)}{\partial S} \Big|_{s_0} = [1.5\mu_s f(S_0) A_0 e^{-RS_0}]$$

Dividing (A.1) by  $A_0 e^{-RS_0}$  and rearranging terms, we obtain

$$\frac{R}{1 - e^{-RH}} = \frac{\frac{\partial k(S)}{\partial S} \Big|_{s_0}}{k(S_0) + 1.5\mu_s f(S_0) - \eta p_0 [(1-\phi)f(S_0) - T((1-\phi)f(S_0))]}$$

$$\equiv \frac{NUM}{DENOM} \quad (\text{A.2})$$

Simplifying and collecting terms, we can rewrite NUM and DENOM in (A.2) as follows:

$$NUM \equiv \left\{ \frac{q}{q_0} [p_0(1-\gamma) - \delta] q_0 + \frac{p}{p_0} [q_0(1-\gamma) + \gamma - (a+b)] p_0 \right\} \\ \times (f(S_0) - T(f(S_0))) + [q_0 + (1-q_0)\gamma + (1-p_0)a] \\ \times (f'(S_0) - T'(f(S_0))) f'(S_0)$$

and

$$DENOM \equiv -\eta p_0 [(1-\phi)f(S_0) - T((1-\phi)f(S_0))] + \mu_0 f(S_0) + \\ \{q_0[p_0(1-\gamma)] + p\gamma + (1-p_0)(a+b) + (1-q_0)\delta\} \\ \times (f(S_0) - T(f(S_0))).$$

Dividing both terms by  $k(S_0) \equiv k_0$ , and observing that

$$\frac{f'(S_0) - T'(f(S_0))) f'(S_0)}{f(S_0) - T(f(S_0))} = \frac{f'(S_0)}{f(S_0)} \frac{1 - \frac{T'(f(S_0))}{f'(S_0)}}{1 - \frac{T(f(S_0))}{f(S_0)}} \equiv \theta \frac{1-T'}{1-\tau_0},$$

$$\frac{(1-\phi)f(S_0) - T((1-\phi)f(S_0))}{f(S_0) - T(f(S_0))} = (1-\phi) \frac{1 - \frac{T((1-\phi)f(S_0))}{(1-\phi)f(S_0)}}{1 - \frac{T(f(S_0))}{f(S_0)}} \equiv (1-\phi) \frac{1-\tau_s}{1-\tau_0},$$

and

$$\frac{f(S_0)}{f(S_0) - T(f(S_0))} = \frac{1}{1-\tau_0},$$

we obtain eq. (2) in the paper

$$\frac{R}{1 - e^{-RH}} =$$

$$\frac{\theta \left[ \frac{1-T'}{1-\tau_0} \right] \left[ \frac{p_0(q_0 + (1-q_0)\gamma) + (1-p_0)a}{k_0} \right] + \varepsilon \left[ \frac{(q_0 + (1-q_0)\gamma - (a+b))p_0}{k_0} \right] + \xi \left[ \frac{(p_0(1-\gamma) - \delta)q_0}{k_0} \right]}{1 - \left( \frac{1-\tau_s}{1-\tau_0} \right) \left[ \frac{\eta p_0(1-\phi)}{k_0} \right] + \left[ \frac{1.5\mu_s}{k_0} \right]}$$

## Appendix B: Elasticities of private returns to education

Let us compute the effects of changes in a 'generic' policy parameter  $\varphi$  on the rate of return  $R$ . Let

$$F(R) \equiv \frac{R}{1 - e^{-RH}}$$

and

$$G(\varphi) \equiv \frac{NUM}{DENOM}.$$

Rewrite eq. (1) or (2) as

$$F(R) - G(\varphi) = 0$$

By the implicit function theorem,

$$\frac{\partial R}{\partial \varphi} = - \frac{\frac{\partial G(\cdot)}{\partial \varphi}}{\frac{\partial F(R)}{\partial R}}$$

Clearly,

$$\frac{\partial F(R)}{\partial R} = \frac{1 - (1 + RH)e^{-RH}}{(1 - e^{-RH})^2} \geq 0,$$

because its numerator is equal to 0 when  $R = 0$  and it is easily confirmed to be an increasing function of  $R$ . (Clearly, the denominator is always non-negative.)

We present the direct computation, by gender, in the next two sections of the Appendix.

### B.1: Elasticities of private returns to education for the male population

Rewrite eq. (1), the FOC from the optimisation problem of a male individual:

$$\frac{R_M}{1 - e^{-R_M H_M}} = \frac{\theta [p_0 + (1 - p_0)a] \left[ \frac{1 - T'}{1 - \tau_0} \right] + \varepsilon [(1 - a - b)p_0]}{\left[ p_0 + (1 - p_0)(a + b) - \frac{1 - \tau_s}{1 - \tau_0} (1 - \phi) \eta p_0 \right] + \left[ \frac{\mu_s}{1 - \tau_0} \right]}$$

Then, let us define:

$$NUM = \theta [p_0 + (1 - p_0)a] \left[ \frac{1 - T'}{1 - \tau_0} \right] + \varepsilon [(1 - a - b)p_0]$$

$$DENOM = \left( \left[ p_0 + (1 - p_0)(a + b) - \frac{1 - \tau_s}{1 - \tau_0} (1 - \phi) \eta p_0 \right] + \left[ \frac{\mu_s}{1 - \tau_0} \right] \right)$$

We first compute the derivative with respect to  $R$ :

$$\frac{\partial F(R)}{\partial R} = \frac{1 - (1 + R_M H_M) e^{-R_M H_M}}{(1 - e^{-R_M H_M})^2} > 0 \text{ and } < 1$$

We proceed by computing the derivatives with respect to the different parameters:

$$\frac{\partial G}{\partial T'} = \frac{-\theta[p_0 + (1-p_0)a] \frac{1}{1-\tau_0}}{DENOM} < 0$$

$$\frac{\partial G}{\partial \tau_0} = \frac{\theta[p_0 + (1-p_0)a] \left[ \frac{1-T'}{(1-\tau_0)^2} \right] [DENOM] - [NUM] \left( -\frac{1-\tau_s}{[1-\tau_0]^2} (1-\phi)\eta p_0 + \mu_s \frac{1}{(1-\tau_0)^2} \right)}{[DENOM]^2} ?$$

$$\frac{\partial G}{\partial \tau_s} = -\frac{\frac{1}{1-\tau_0} (1-\phi)\eta p_0 NUM}{(DENOM)^2} < 0$$

$$\frac{\partial G}{\partial a} = \frac{\left( \theta \left[ (1-p_0) \frac{1-T'}{1-\tau_0} \right] - \varepsilon p_0 \right) [DENOM] - [NUM] (1-p_0)}{[DENOM]^2} ?$$

$$\frac{\partial G}{\partial b} = \frac{[-\varepsilon p_0] [DENOM] - [NUM] (1-p_0)}{[DENOM]^2} < 0 \quad (rem: p < 1)$$

$$\frac{\partial G}{\partial \mu_s} = -\frac{NUM \frac{1}{1-\tau_0}}{(DENOM)^2} < 0$$

$$\frac{\partial G}{\partial p_0} = \frac{\left[ \theta \left[ \frac{1-T'}{1-\tau_0} (1-a) \right] + \varepsilon (1-a-b) \right] DENOM - NUM \left[ 1-a-b - \frac{1-\tau_s}{1-\tau_0} (1-\phi)\eta \right]}{DENOM^2} ?$$

$$\frac{\partial G}{\partial \varepsilon} = \frac{[(1-a-b)p_0]}{DENOM} > 0$$

$$\frac{\partial G}{\partial \theta} = \frac{[p_0 + (1-p_0)a] \left[ \frac{1-T'}{1-\tau_0} \right]}{DENOM} > 0$$

The elasticities with respect to  $\varphi$ , for males, are given by:

$$\frac{\partial R}{\partial \varphi} \frac{\varphi}{R} = \frac{\varphi}{R} \frac{\frac{\partial G(.)}{\partial \varphi}}{\frac{\partial F(R)}{\partial R}}$$

where  $\varphi$  is any one of the policy parameters introduced above.



## B.2: Elasticities of private returns to education for the female population

Rewrite eq. (2), the FOC from the optimisation problem of a female individual:

$$\frac{R_W}{1 - e^{-R_W H_W}} =$$

$$\frac{\theta \left[ \frac{1-T'}{1-\tau_0} \right] \left[ p_0(q_0 + (1-q_0)\gamma) + (1-p_0)a \right] + \varepsilon \left[ (q_0 + (1-q_0)\gamma - (a+b))p_0 \right] + \xi \left[ (p_0(1-\gamma) - \delta)q_0 \right]}{\left[ p_0(q_0 + (1-q_0)\gamma) + (1-p_0)(a+b) + (1-q_0)\delta \right] - \left[ \frac{1-\tau_s}{1-\tau_0} \eta p_0(1-\phi) \right] + \left[ 1.5\mu_s \frac{1}{1-\tau_0} \right]}$$

Then, let us define:

$$NUM = \theta \left[ \frac{1-T'}{1-\tau_0} \right] \left[ p_0(q_0 + (1-q_0)\gamma) + (1-p_0)a \right] + \varepsilon \left[ (q_0 + (1-q_0)\gamma - (a+b))p_0 \right] + \xi \left[ (p_0(1-\gamma) - \delta)q_0 \right]$$

$$DENOM = \left[ p_0(q_0 + (1-q_0)\gamma) + (1-p_0)(a+b) + (1-q_0)\delta \right] - \left[ \frac{1-\tau_s}{1-\tau_0} \eta p_0(1-\phi) \right] + \left[ 1.5\mu_s \frac{1}{1-\tau_0} \right]$$

The derivative with regard to  $R$  is, obviously, the same. We proceed by computing the derivatives with respect to the different parameters:

$$\frac{\partial G}{\partial \gamma} = \frac{\left[ \theta \left[ \frac{1-T'}{1-\tau_0} \right] p_0(1-q_0) + \varepsilon \left[ (1-q_0)p_0 \right] - \xi p_0 q_0 \right] DENOM - NUM p_0(1-q_0)}{DENOM^2} ?$$

$$\frac{\partial G}{\partial \delta} = \frac{\xi [-q_0] DENOM - NUM [1-q_0]}{DENOM^2} ? \quad (\text{always} < 0 \text{ if } q_0 < 1)$$

$$\frac{\partial G}{\partial a} = \frac{\left[ \theta \left[ \frac{1-T'}{1-\tau_0} \right] (1-p_0) - p_0 \varepsilon \right] DENOM - NUM (1-p_0)}{DENOM^2} ?$$

$$\frac{\partial G}{\partial b} = \frac{-\varepsilon p_0 DENOM - NUM (1-p_0)}{DENOM^2} < 0 \quad (\text{rem: } p_0 < 1)$$

$$\frac{\partial G}{\partial T'} = \frac{-\theta \frac{1}{1-\tau_0} \left[ p_0(q_0 + (1-q_0)\gamma) + (1-p_0)a \right]}{DENOM} < 0$$

$$\frac{\partial G}{\partial \tau_0} = \frac{\left[ \theta \frac{1-T'}{(1-\tau_0)^2} (p_0(q_0 + (1-q_0)\gamma) + (1-p_0)a) \right] DENOM - NUM \left[ -\frac{1-\tau_s}{(1-\tau_0)^2} \eta p_0(1-\phi) + 1.5\mu_s \frac{1}{(1-\tau_0)^2} \right]}{DENOM^2} ?$$

$$\frac{\partial G}{\partial \tau_s} = \frac{-NUM \left[ \frac{1}{1-\tau_0} \eta p_0(1-\phi) \right]}{DENOM^2} < 0$$

$$\frac{\partial G}{\partial \mu_s} = \frac{-NUM \frac{1.5}{1-\tau_0}}{DENOM^2} < 0$$

$$\frac{\partial G}{\partial p_0} = \frac{\left[ \theta \left[ \frac{1-T'}{1-\tau_0} \right] [(q_0 + (1-q_0)\gamma) - a] - \varepsilon [q_0 + (1-q_0)\gamma - (a+b)] + \xi [(1-\gamma)q_0] \right] DENOM + \left[ -NUM \left[ q_0 + (1-q_0)\gamma - (a+b) - \frac{1-\tau_s}{1-\tau_0} \eta (1-\phi) \right] \right]}{DENOM^2} ?$$

$$\frac{\partial G}{\partial \varepsilon} = \frac{[(q_0 + (1-q_0)\gamma - (a+b))p_0]}{DENOM} > 0$$

$$\frac{\partial G}{\partial q_0} = \frac{\left[ \theta \left[ \frac{1-T'}{1-\tau_0} \right] p_0(1-\gamma) + \varepsilon [(1-\gamma)p_0] + \xi [p_0(1-\gamma)] \right] DENOM - NUM [p_0(1-\gamma) - \delta]}{DENOM^2} ?$$

$$\frac{\partial G}{\partial \xi} = \frac{(p_0(1-\gamma) - \delta)q_0}{DENOM} ?$$

$$\frac{\partial G}{\partial \theta} = \frac{\left[ \frac{1-T'}{1-\tau_0} \right] [p_0(q_0 + (1-q_0)\gamma) + (1-p_0)a]}{DENOM} > 0$$

As before, the elasticities with respect to  $\varphi$ , for females in this case, are given by:

$$\frac{\partial R}{\partial \varphi} \frac{\varphi}{R} = \frac{\varphi}{R} \frac{\frac{\partial G(.)}{\partial \varphi}}{\frac{\partial F(R)}{\partial R}}$$

where  $\varphi$  is any one of the policy parameters introduced above.

In the text we only present, in Table 4, the numerical values of the elasticities of the private returns to education, by gender, with respect to unemployment benefits,  $a$  and  $b$ , marginal and average tax rates,  $T'$  and  $\tau_0$ , and maternity leave and child-care benefits,  $\gamma$  and  $\delta$ .

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## Imprint

IAB-Discussion Paper 20/2011

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