CENTRE FOR APPLIED MACROECONOMIC ANALYSIS

The Australian National University

CAMA Working Paper Series **April, 2007**

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CAMA Working Paper 8/2007
http://cama.anu.edu.au

The Impact of Fiscal Policy on Labor Supply and Education in an Economy with Household and Market Production*

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March 29, 2007

Abstract

This paper considers optimal educational investment and labour supply with increasing returns to scale in the earnings function In so doing we develop the work of Rosen (1983), who first highlighted the increasing returns argument that arises because private returns to human capital investment are increasing in subsequent utilization rates. We demonstrate that increasing returns generates task specialisation - individuals choose to become either home specialists or work specialists. With heterogeneous workers, we show for certain types, that a tax on labour income leads to large, non-marginal substitution effects; i.e. those with a comparative advantage in home production are driven out of the market sector. Tax deadweight losses are consequently large. Consistent with the theory, our empirical results, using a cross-country panel, find that gender differences in labor supply responses to tax policy can play an important role in explaining differences in aggregate labor supply across countries.

Keywords: Increasing returns, fiscal policy, household production, labor supply

JEL Classification: H24, J13, J24, J31, J42.

*We are grateful to the ARC for financial support under Discovery Project Grant No. DP0556740, to Tim Hatton and Adrian Pagan for helpful discussions, to Florence Jaumotte for providing access to her OECD tax database, and to Hiau Joo Kee for excellent data assistance. Melvyn Coles also thanks the Barcelona Economics Program of CREA for support.

1 Introduction

A number of recent studies show that heterogeneity in tax rates explains differences in labor supply across OECD countries.[1] But the papers highlight a puzzle: that the Scandinavian countries are characterized by both high tax rates *and* high labor supply. Although these studies focus on home as well as market production, they typically do not consider how tax policy can affect male and female labor supply differentially. An exception is Ragan (2004), who argues that heterogeneity in female labor supply contributes significantly to aggregate differences in labor supply across OECD countries. An important component of her argument is that home production is typically undertaken by women who are most responsive to changes in fiscal policy.

We suggest a further avenue through which such fiscal policies can affect labor market outcomes - investment in market human capital. A critical feature of our argument is there are increasing private returns to general human capital k and labour supply l in earnings, as noted earlier by Rosen (1983).[2] Simply put suppose, as in the textbook case, that labour market earnings are hours worked, l, times the wage paid, w. Assuming wage $w = w(k)$ increases with human capital k, then the earnings function $y(l, k) = lw(k)$ exhibits increasing returns. The argument for increasing returns appears particularly compelling when viewed from a life-cycle perspective. For example suppose an individual either works a 40 hour week or does not participate. Then labor supply might be re-interpreted as an individual's average participation rate over a lifetime. If all have an expected working lifespan of say 50 years, then a mother who takes 20 years out of the workforce to raise a family has average participation rate of 30/50=60%. Absent of discounting, her total lifetime earnings is then the weekly market wage for her skills, $w = w(k)$, times her average participation rate; i.e. her lifetime gross earnings are quadratic in participation l and wage $w(k)$. Typically the literature assumes constant or decreasing returns so that a standard marginal tax analysis applies (i.e. second order conditions

[1] See *inter alia* Prescott (2003), Rogerson (2003), Davis and Henrekson (2004), and Olovsson (2004). These studies focus on macroeconomic time series fluctuations and do not endogenize educational investments, a central focus of our paper. Earlier studies investigating taxes and labor supply from a microeconomic perspective include Apps and Rees (1999) and references therein.

[2] Our approach is quite distinct from the literature that investigates labor supply and wage formation over the lifecycle and in which 'experience capital'can therefore play a role. Human capital in our two-period approach refers to that accumulated prior to market sector entry rather than to that accumulated on-the-job.

are automatically satisfied). We do not take that approach here.[3]

An important feature for tax policy is that labour supply and human capital are also complementary inputs in labour market earnings. As is well known, a tax on labour income implies workers will substitute to home production. But lower labour supply (i.e. a lower utilization rate of capital k) lowers still further the return to human capital. Lower skills investment then implies a lower wage rate and thus a lower return to labour supply, and so on. The skills investment decison generates a tax multiplier effect on labour supply.[4] Indeed we shall show, with increasing returns as described above, the substitution effect for some types can be very large, driving those with a comparative advantage in home production out of the labour market. Most importantly this large substitution effect is non-marginal, generating a deadweight loss which is much bigger than a standard Harberger triangle.

In summary, our analysis provides three critical insights. First, even if all workers have the same Mincerian return to education, they do not all have the same marginal return to education: the marginal return to education depends on future expected labor supply (i.e. the utilisation rate of that capital) which in turn depends on future home productivity. Second, increasing returns implies discrete switches in behaviour - a standard marginal analysis of taxes on labour supply is inappropriate. Specifically increasing returns endogenously generates role specialisation - those with sufficiently low workplace ability or high home productivity become "home specialists": they invest in low amounts of (workplace) skills k and have low partipcation rates in the labour market. "Work specialists" instead invest in large amounts of market capital k and have high particpation rates. At the margin between the two specialisms, an individual compares the payoff to low k and low labor supply against investing in much higher k; i.e. education and participation increases by a large amount across the specialism threshold.

The third insight is that an increase in tax rates or a more generous social security program reduces the return to working in the labor market and so leads to lower education and partici-

[3] Rios-Rull (1993) models skills acquisition in a competitive economy with home and market production but his model does not include taxation. To our knowledge, no studies have modeled educational investment and labor supply in an economy with home production and with taxation. However Gomme, Rogerson, Rupert and Wright (2004) suggest that real business cycle models might benefit from moving away from the representative agent assumption and considering how hours of market work fluctuate across various subgroups of the population. They suggest that human capital accumulation could play an important role.

[4] Imai and Keane (2003) also argue that allowing for endogenous human capital accumuation leads to much larger labor supply elasticities, although in a different context.

pation rates. This is a standard insight. But what is new is that the optimal switch to "home specialist" takes into account the *total* tax taken by the government should the worker instead invest fully in education and work full time. Thus the provision of a social security progam and average tax rates over a *range* of earnings, rather than a single marginal tax rate, is central to this decision. Furthermore should women have higher expected home productivity than men, then female education choice and labour market participation will respond differently to tax policy.

In the empirical section we compare education and labour market participation rates by gender using an unbalanced panel of 21 OECD countries (1980-2001). With almost no exception, in each country female labour market participation rates and educational investment have been increasing over this time period (Jaumotte (2004)). A second important feature of the data is that there is wide cross-country dispersion in female labour force participation rates, and very little in male particpation rates. There is also wide cross-country dispersion in tax rates (and tax treatment of second earners), public child care provision (which we interpret as an employment subsidy for home specialists) and child benefits. Consistent with the theory we find that policies which positively affect female labour market participation choice also positively affect female education choice.[5] Also female market responses to tax parameters are typically large. In contrast male participation rates are largely unresponsive to tax parameters, a surprising exception being public childcare provision which is strongly negative (which, of course, is strongly positive for women). But given the current "puzzle" that Scandinavian countries are characterized by both high tax rates *and* high labor supply, an interesting exercise is to infer how participation rates in the U.S. would change if the U.S. were to switch to Swedish tax policies. Although Sweden has higher average tax rates, it treats second earners more favourably. It also has much more generous public childcare benefits which essentially subsidise female labour market participation. Our panel estimates suggest that U.S. female participation rates would increase significantly with a switch to Swedish policies, while male participation rates would be little affected. Thus the puzzle mentioned in the opening paragraph, that employment rates are high in Sweden despite high tax rates, disappears once we distinguish

[5] With the one exception being for the variable measuring child benefits and tax allowances

between male and female labour force participation choice.

The paper is set out as follows. Section 2 describes the model and section 3 establishes optimal labor supply and optimal education depending on a worker's expected productivity both in the home and the workplace. Section 4 analyzes the deadweight losses associated with taxes and income transfer programs. Section 5 presents empirical support for the predictions of the model by exploring the impact of fiscal policy on employment rates and years of education, using panel data from 21 OECD countries. The final section concludes.

2 The Model

Young people typically make their human capital investments prior to meeting their future partners and before raising families. We therefore consider educational choice in a two period framework in which educational choice is made in the first period given expectations of second period home productivity. This timing is not critical to the results - by assumption there are (joint) increasing returns in earnings regardless of whether education e and labor supply l are chosen simultaneously or sequentially. The essential asymmetry of interest arises from governments taxing labor market income but not home production. Our central point is that, with increasing returns, such taxation can generate large, non-marginal substitution effects for certain types. To keep the discussion of second order conditions manageable, while illustrating clearly the underlying economic issues, the model is kept deliberately simple.

Thus consider a representative worker who is born with ability a and has expectations of future home productivity b. In the first period, the worker can invest in e units of workplace human capital which - consistent with the Mincerian human capital literature - we refer to as education. In the second period, home productivity b is realised. The worker then has a unit time endowment where time $l \in [0, 1]$ is spent working in the labor market and $h = 1 - l$ is time spent on home activities. Traditionally h might be interpreted as leisure, but here we think of it as time spent raising children and carrying out other domestic activities.[6]

For simplicity suppose the market wage rate $w = w_0(a + e)$ where $w_0 > 0$ describes the

[6] For people with no children h might be pure leisure, although time use studies show that, even in partnered households without children, considerable time is spent on home-related activities such as cooking and cleaning.
.

Mincerian rate of return to education (and is the same for all). Also assume the cost of attaining education level e is $c_0 e$ where $c_0 > 0$ and is also the same for all - it is straightforward to show that the results below also hold when higher ability types have lower education costs.[7] To keep the exposition clear, we abstract from income effects by assuming c_0 is a disutility cost (i.e. education is costly as it requires passing exams) and that all have zero initial wealth. Further suppose a linear tax schedule where, given gross labor market earnings $y_G = wl$, after-tax income is

$$y = S + (1 - \tau)wl.$$

Thus $S > 0$ are social security benefits paid to individuals, and $\tau \in [0, 1]$ is the marginal rate of income tax. Note that S/τ defines a break even level of income: workers with pre-tax earnings $y_G < S/\tau$ receive net social security payment $S - \tau y_G$ from the government, while those earning $y_G > S/\tau$ pay net tax $\tau y_G - S$. The second period budget constraint is then

$$pC \leq S + (1 - \tau)wl = S + (1 - \tau)w_0(a + e)l$$

where p is the price of the consumption good which we normalise to one. Note the critical non-convexity as described in the Introduction: (after-tax) earnings have increasing returns in e and l.

Again for simplicity assume second period utility is additively separable in consumption and home production $h = 1 - l$; i.e.

$$U_2(C, h) = u(C) + bx(h)$$

where u, x are strictly increasing, strictly concave and twice differentiable functions. Note this specification implies workers with higher b have a higher marginal return to home production. We assume b is exogenous; i.e. human capital investment e does not affect second period

[7] A more general specification might instead assume $w(.)$ is non-linear and that the cost of education e is $\widehat{c}_a(e)$ where $\widehat{c}_a(.)$ is an increasing and strictly convex function which depends on type. Such extensions are qualitatively unimportant. Given any educational investment k, and hence corresponding educational attainment $e = \widehat{c_a}^{-1}(k)$, second period gross earnings $y_G = lw(a, \widehat{c_a}^{-1}(k))$ continue to imply joint increasing returns to l and k. Assuming $w(.)$ is linear is a useful simplification which implies w_0 can be interpreted as the Mincer return to education. Of course linear returns and costs could potentially imply an individual makes an unboundedly large investment. A strictly concave utility function, however, ensures this is never optimal.

home productivity b. While restrictive, our results only need that e has a much larger effect on workplace productivity. As the scope for investment in home productivity seems significantly less than the scope for investment in workplace human capital, this simplification appears reasonable.

As utility is strictly increasing in C, the budget constraint always binds and so consumption $C = S + (1 - \tau)y_G$. As the time constraint implies $h = 1 - l$, the worker's second period optimisation problem is equivalent to choosing $l \in [0, 1]$ to solve

$$\max_{l \in [0,1]} u(S + (1 - \tau)w_0 \alpha l) + bx(1 - l). \tag{1}$$

where productivity $\alpha = a + e$ is given in the second period. This objective function is strictly concave in l and so standard first order conditions fully describe the maximum. Claim 1 below describes those conditions. Given optimal labour supply and tax parameters (S, τ), second period utility is

$$U_2^*(\alpha, b; S, \tau) = \left[\max_{l \in [0,1]} u(S + (1 - \tau)w_0 \alpha l) + bx(1 - l) \right].$$

The worker in the first period chooses education to solve

$$V_1(a, b; S, \tau) = \max_{\alpha \geq a} \left[U_2^*(\alpha, .) - c_0[\alpha - a] \right]. \tag{2}$$

As after-tax earnings have increasing returns to scale, $U_2^*(\alpha, .)$ is not concave in α. The following not only determines the optimal education choice given type (a, b), it also describes how varying the tax program (S, τ) affects that decision and ex-post labour supply.

3 Optimal Education and Labor Supply

In this section we take the tax parameters (S, τ) as given and solve for the worker's optimal first period education choice and second period labor supply. The section that follows then considers how changing tax parameters (S, τ) affects those choices.

3.1 Second period labor supply

Given second period productivity parameters (α, b), the worker's optimal second period labor supply choice, properly denoted $l^*(\alpha, b; S, \tau)$, solves (1). As (S, τ) is held fixed in this section, however, we simplify notation here by subsuming reference to S, τ.

As there may be corner solutions, define the following functions

$$\begin{aligned} b_{PT}(\alpha) &= (1-\tau)\alpha w_0 u'(S)/x'(1), \\ b_{FT}(\alpha) &= (1-\tau)\alpha w_0 u'(S+(1-\tau)w_0\alpha)/x'(0). \end{aligned}$$

Note that b_{PT} is linear and increasing in α, but b_{FT} is non-linear and may be a decreasing function of α (see Figures 1a and 1b below). For now note that concavity of u and x implies $b_{PT} \geq b_{FT}$ with strict inequality if either u or x is strictly concave. Figures 1a and 1b plot these functions when $u(.)$ exhibits constant relative risk aversion (CRRA).

As the objective function in (1) is concave in l, the Kuhn-Tucker first order conditions fully characterize $l^*(.)$. Claim 1 now describes those conditions.

Claim 1. Optimal Second Period Labor Supply.

Given $\alpha, b \geq 0$, optimality implies:

(i) $l^* = 0$ if $b > b_{PT}$;

(ii) $l^* = 1$ if $b < b_{FT}$;

(iii) otherwise l^* is described by the first order condition

$$bx'(1-l^*) = \alpha w_0(1-\tau)u'(S+(1-\tau)\alpha w_0 l^*). \tag{3}$$

Claim 1 describes the Kuhn-Tucker conditions implied by (1). People with very high home productivity, $b > b_{PT}$, do not participate in the labor market; they choose $l^* = 0$. Conversely people with very low home productivity, $b < b_{FT}$, participate in full time employment; they choose $l^* = 1$. In the intermediate region where $b \in (b_{FT}, b_{PT})$, optimal labor supply implies $l^* \in (0, 1)$ and (3) describes the optimal trade-off between home production and employment in the market sector. Although one might interpret l^* as the worker's average participation rate over a working lifetime, the taxonomy used here is that the interval $b \in (b_{FT}, b_{PT})$ is the part-time region, the region $b \leq b_{FT}$ is the full participation region while $b \geq b_{PT}$ is the non-participant region.

Given this description of optimal labor supply in the second period, the next step is to determine the optimal education choice e in the first period. We now show there are increasing marginal returns to education.

The optimal education choice e depends on how second period labor supply l^* varies with productivity. Standard comparative statics establish that labor supply l^* is strictly decreasing in home productivity in the part-time region (of course l^* is constant in the constrained regions). If the worker is risk neutral, labor supply l^* is unambigously increasing with α. Risk aversion is more complicated as there are income effects. Suppose for example a constant relative risk aversion (CRRA) utility function, $u(C) = C^{1-\sigma}/(1-\sigma)$ where $\sigma \geq 0$ is the degree of relative risk aversion. Claim 2 describes how l^* varies with α in this case.

Claim 2. Optimal Labor Supply with CRRA.

(i) If $\sigma < 1$ then l^* is strictly increasing in α for all $b \in (b_{FT}, b_{PT})$. Further b_{PT}, b_{FT} are strictly increasing in α.

(ii) If $\sigma > 1$ then

(a) for low productivities $\alpha < S/[(\sigma-1)(1-\tau)w_0]$, l^* and b_{FT} are both increasing in α;

(b) for $\alpha > S/[(\sigma-1)(1-\tau)w_0]$, b_{FT} is decreasing in α. Further, a $b^c \in (b_{FT}, b_{PT})$ exists where l^* is strictly increasing in α for $b \in (b^c, b_{PT})$ and strictly decreasing in α for $b \in (b_{FT}, b^c]$.

Proof is in the Appendix.

Figures 1a and 1b depict these two cases. Figure 1a describes the thresholds b_{PT} and b_{FT} for low levels of risk aversion, $\sigma < 1$. Claim 2 implies labor supply is always increasing in α. Further, α high enough implies the worker takes full time employment $l^* = 1$. Figure 1b holds when there is high risk aversion, $\sigma > 1$. Note that l^* is decreasing in α for α high enough - high risk aversion implies the shadow value of consumption becomes very small at high income levels and the worker instead consumes more 'leisure' (home production). Standard comparative statics establish that b^c, as drawn in Figure 1b, is strictly increasing in α.

Figures 1a, 1b here.

3.2 First period education

Given this characterization of l^* we now consider the optimal education choice in the first period. Note that a worker who invests to productivity level $\alpha \geq a$ in the first period obtains expected utility

$$U_1(\alpha, .) \equiv [u(S + (1 - \tau)\alpha w_0 l^*) + bx(1 - l^*)] - c_0[\alpha - a].$$

A most important object for what follows is

$$MR = (1 - \tau)w_0 l^* u'(C), \tag{4}$$

where $C = S + (1 - \tau)\alpha w_0 l^*$. Totally differentiating U_1 with respect to α, noting that l^* is chosen optimally, the Envelope Theorem implies

$$\frac{dU_1}{d\alpha} = MR - c_0.$$

Hence MR describes the worker's marginal return to education.

First consider the simplest case, that workers are risk neutral and so without further loss of generality $u(C) = C$. Then $MR = (1 - \tau)w_0 l^*$. Thus the marginal return to education is the Mincer rate of return (net of tax) multiplied by expected labor supply. Since Claim 2 with $\sigma = 0$ implies l^* is increasing in α (strictly in the part-time region), MR is an increasing function of α. That is, risk neutrality guarantees there are increasing marginal returns to education. The reason is simple - very low α workers who do not participate in the labor market have a zero marginal return to workplace capital investment. In contrast, very high productivity workers who choose $l^* = 1$ have the highest return. Increasing returns then occur as labor supply, and hence the utilisation rate of human capital, is increasing in productivity.

The case with strictly risk averse workers is more complicated because the marginal return to education depends on the marginal utility of consumption. We now simplify by assuming a

CRRA utility function with $\sigma \leq 1$.[8] Noting that $b = b_{PT}(\alpha)$ is linear in α, we can invert this function and so define $\alpha_{PT} = (b_{PT})^{-1}(b)$ where

$$\alpha_{PT} = bx'(1)/[(1-\tau)w_0 u'(S)].$$

In Figure 1a, $\alpha = \alpha_{PT}(b)$ corresponds to the locus labelled b_{PT}.

Note that $\sigma < 1$ and Claim 2 imply $b = b_{FT}(\alpha)$ is a strictly increasing function. Hence its inverse function is also well-defined. Hence we can define $\alpha_{FT} = (b_{FT})^{-1}(b)$ and $\alpha_{FT}(.)$ is also an increasing function. In Figure 1a, $\alpha_{FT}(b)$ corresponds to the locus labelled b_{FT}. Figure 1a and (4) now imply $MR = MR(\alpha, b)$ where

$$\begin{aligned} MR &= 0 \text{ if } \alpha \leq \alpha_{PT}(b) \\ &= (1-\tau)w_0 l^* u'(S + (1-\tau)\alpha w_0 l^*) \text{ if } \alpha \in (\alpha_{PT}(b), \alpha_{FT}(b)) \\ &= (1-\tau)w_0 u'(S + (1-\tau)\alpha w_0) \text{ if } \alpha \geq \alpha_{FT}(b). \end{aligned} \tag{5}$$

Figure 2 below graphs MR by productivity α, given $\sigma \leq 1$ and b fixed, and on the assumption MR is increasing over the part-time region. For productivities $\alpha \leq \alpha_{PT}(b)$, the worker does not particpate in the labour market and so $MR = 0$. For productivities $\alpha \geq \alpha_{FT}(b)$,the worker chooses $l^* = 1$ and MR is then decreasing in α as the marginal utility of consumption decreases with after tax earnings. There are necessarily increasing returns to education for α around the non-participant margin, $\alpha = \alpha_{PT}$, because returns become strictly positive at that point. However as earnings increase with α, the marginal utility of consumption decreases and so it is not necessarily the case that MR is increasing over the entire part-time region. For ease of exposition, we shall assume MR is single peaked in this region. Although MR is continuous in α (as labor supply is continuous) its slope is not continuous at the margins α_{PT}, α_{FT} as $\partial l^*/\partial\alpha$ is constrained equal to zero outside of the part-time region.[9]

[8] The results are qualitatively identical with $\sigma > 1$ but the exposition is more complicated as Figure 1b implies the full participation region may not exist (e.g. when b is large). The properties of MR with $\sigma > 1$ are identical to the case $\sigma \in (0,1)$ as drawn in Figure 2; there are zero returns for α in the non-participation region, increasing marginal returns in the early part of the part-time region (as returns become strictly positive) and decreasing marginal returns for large enough α (as labour supply is then decreasing with productivity - see Figure 1b) but the full particpation region may not exist.

[9] See the Appendix which describes the slope of MR.

Figure 2 here.

Given this characterization of $MR(.)$, we can now describe the optimal education decision of a worker given ability a and expected home productivity b. Recall that the worker's first period problem is

$$\max_{\alpha \geq a} \left[U_2^*(\alpha, b) - c_0[\alpha - a]\right]$$

where $MR \equiv \partial U_2^*/\partial\alpha$. The necessary conditions for optimality imply either a corner solution

(i) $\alpha = a$ and $MR(a, b) \leq c_0$;

or an interior optimum

(ii) $\alpha = \alpha^*(b)$ where $MR(\alpha^*, b) = c_0$.

Assuming MR is single-peaked as drawn in Figure 2 implies there are two candidate optima. A local maximum occurs where $MR(\alpha, b) = c_0$ on the decreasing portion of the marginal revenue curve and we let $\alpha^*(b)$ denote that solution (where MR single-peaked implies α^* is unique). The other candidate maximum is that the worker chooses zero education where such a choice is optimal only if $MR(a, b) \leq c_0$.

Consider then workers with ability $a < \alpha^*$ and $MR(a, b) < c_0$; e.g. workers with ability $a < \alpha_{PT}(b)$ for whom $MR(a, b) = 0$. With increasing returns to education, these workers compare the value of no education, $\alpha = a$, against educating up to $\alpha = \alpha^*(b)$. Define

$$V(a, b) = \int_a^{\alpha^*} (MR(\alpha, b) - c_0)\, d\alpha$$

which describes the surplus to educating up to α^*. If $V > 0$ the optimal education choice implies $\alpha = \alpha^*(b)$ as it generates positive value relative to no education. The converse is implied by $V < 0$; the worker is better off choosing no education $\alpha = a$. The optimal education choice therefore depends on the sign of V.

Figure 2 depicts the critical ability a^c where $V(a^c, b) = 0$; i.e. the two shaded areas are equal. A worker with ability $a = a^c$ is indifferent between no education and education to α^*. As a^c must lie on the increasing portion of MR, it follows that $a^c < \alpha_{FT}$. Proposition 1 now establishes that lower ability workers, those with $a < a^c$ choose zero education, while higher ability workers invest to $\alpha^* \gg a^c$. The large discontinuity arises as there are increasing marginal returns to education.

Proposition 1. For given b, suppose MR is single-peaked and suppose that peak occurs at ability $\widehat{a}$. Then for any $c_0 \in (0, MR(\widehat{a}, .))$, an ability $a^c < \widehat{a}$ exists where:

(i) workers with ability $a < a^c$ choose $\alpha = a$ (no education) and ex-post choose low labor supply;

(ii) workers with ability $a \in [a^c, \alpha^*(a)]$ choose $\alpha = \alpha^*(a) \gg a$ and ex-post choose much higher labor supply.

Proof. For any $c_0 < MR(\widehat{a}, .)$, continuity and singlepeakedness of MR implies an $a^c < \widehat{a}$ exists where $V(a^c, b) = 0$ (though a^c may be negative). As

$$\frac{\partial V}{\partial a} = c_0 - MR(a, b)$$

it follows immediately that $V(a, b) < 0$ for $a < a^c$. Thus workers with ability $a < a^c$ choose no education. It also follows straightforwardly that $V(a, b) > 0$ for all $a \in [a^c, \alpha^*)$ (as $V(\alpha^*, b) = 0$) and so such types invest to α^*. This completes the proof of Proposition 1.

Increasing returns to education implies discontinuous education choice. Low ability types with $a < a^c$ choose no education and, as $a^c < \widehat{a} \leq \alpha_{FT}$, these workers either do not participate in the labor market, or only take part-time employment. Workers with sufficiently high ability however choose investment $\alpha^* > a$ and, if $\alpha^* > \alpha_{FT}$ as drawn in Figure 2, participate *ex post* in full time employment. Of course it is the switch to full time employment which makes the *ex ante* education decision worthwhile.

We refer to workers with abilities $a \leq a^c(b)$ as home specialists: such workers do not invest in workplace human capital and have relatively low labor supplies $l^* < 1$. An unrealistic implication of Proposition 1, however, is that very high ability workers, those with abilities $a \geq \alpha^*(b)$ also choose no education. This feature occurs as we have assumed risk averse workers, a wage function $w(a, e)$ which is additive in a and e and education costs which are the same for all. This feature disappears if we instead assume workers are risk neutral, a wage function $w(a, e)$ where ability and education are complementary inputs (so that higher ability workers have a greater Mincerian return to education) and/or education costs c_a which decrease with ability a. Higher ability types will then invest in more education. We do not consider such extensions since the increasing returns to education issue, which is of central interest here, is clearly robust to such variations.

Proposition 2 now shows how the marginal home specialist depends on home productivity.

Proposition 2. Home specialists.

$a^c(b)$ is increasing in b.

Proof is in the Appendix.

Home specialists compare the payoff of choosing no education against investing up to productivity $\alpha = \alpha^* \gg a$. An increase in home productivity increases the opportunity cost of working in the market sector and so lowers the relative return to education. Hence workers with greater home productivity are more likely to be home specialists.

4 Policy and Welfare

The previous section characterized the optimal education investments and ex-post labor supply choices of individuals given tax policy parameters (S, τ). The central feature is that the market dichotomises into *home specialists*, those with abilities (a, b) satisfying $a < a^c(b)$ who choose no education and have low market sector participation rates, and *work specialists*, those with abilities $a > a^c(b)$ who invest significantly in education and have high participation rates. We now consider how changes in tax policy affect those choices and describe the corresponding deadweight losses.

As the optimal choices depend on the underlying tax policy (S, τ), we now extend the notation. Specifically, optimal labor supply is now properly denoted $l = l^*(\alpha, b; S, \tau)$, the marginal return to education is $MR(\alpha, b; S, \tau)$, and the marginal home specialist is $a = a^c(b; S, \tau)$. For ease of exposition we maintain a CRRA utility function with $\sigma \leq 1$.

Proposition 3. The Effect of Social Security and Income Tax on Home Specialists.

$a^c(b; S, \tau)$ is strictly increasing in S and τ.

Proof is in the Appendix.

With increasing returns to education, the marginal home specialist compares no education -

which implies ex-post productivity $\alpha = a$ (resulting in low ex-post labor supply) - with investing to productivity $\alpha = \alpha^* \gg a$ (resulting in high ex-post labor supply). As an increase in the income tax rate reduces the return to education, this implies a^c increases with τ - more workers become home specialists.

The impact of social security on education incentives is more subtle. The insight is that home specialists have low earnings *ex post* (their labor market productivity is low and they choose low labor supply). As their marginal utility of consumption is relatively high, an increase in S raises their marginal payoff more relative to being educated and working full-time with relatively high earnings. The presence of social security benefits therefore lowers the value V of a switch to a higher education level (and higher consumption), and so increases a^c. This disincentive disappears if $u(.)$ is linear.

Booth and Coles (2007) consider a related framework with no taxation $S = \tau = 0$ but the labour market is imperfectly competitive. They consider the impact of a subsidy paid to workers conditional on labour market participation. Such employment subsidies decrease a^c, thus resulting in increased particpation **and** increased education rates. This occurs as an employment subsidy increases the return to labour and so increases labour supply. Increased labour supply increases the marginal return to education and a^c decreases. Clearly state expenditure on preschool childcare acts as an employment subsidy for women with young children. Another example of a targeted employment subsidy is tax-exempt childcare vouchers.[10]

4.1 Deadweight Losses

Given the labor market is competitive and there are no externalities by assumption, the marginal social return to investment is simply the private marginal return when $S = \tau = 0$. Hence define the marginal social return to education:

$$SR(\alpha, b) = MR(\alpha, b; 0, 0).$$

[10] The UK recently introduced a scheme whereby Childcare Vouchers are exempt from Tax and National Insurance up to the amount of £55 per week. See http://www.hmrc.gov.uk/childcare/ .

Note that the marginal social return to education is a special case of the previous analysis and so there are increasing returns. Let $a^S(b) \equiv a^c(b;0,0)$ denote the socially efficient marginal home specialist and $\alpha^S(b) \equiv \alpha^*(b;0,0)$ denote the socially efficient investment level (for higher ability types). Note for any $S, \tau > 0$, Proposition 3 implies $a^S(b) < a^c(b;S,\tau)$.

Figure 3 plots SR and MR for given $S, \tau > 0$. The proof of Proposition 3 implies MR must lie below SR. It can also be shown that α_{PT}, α_{FT} lie to the right compared to their values when $S = \tau = 0$. As SR is a special case of MR, it also exhibits increasing returns around the non-participant margin.

Figure 3 here.

Figure 3 depicts the deadweight losses implied by the tax program for the marginal home specialist a^c. As $a^S < a^c$, the socially optimal outcome is that the worker invests to α^S where $SR = c_0$. If the marginal home specialist pursues the positive education decision, and increases productivity to the privately optimal level α^*, then the corresponding deadweight loss due to the tax program is the light-shaded Harberger triangle labelled DWL_2. At productivity level α^*, the worker obtains $MR = (1-\tau)w_0u'(C)$ and the tax wedge implies the worker underinvests in education. For workers with higher abilities, $a > a^c$, the deadweight loss implied by the tax program always corresponds to such (small) Harberger triangles.

But suppose instead the worker with ability a^c takes the no education option, $\alpha = a^c$. As the worker is indifferent between $\alpha = a$ and α^*, the additional deadweight loss due to this no education choice is the area between SR and MR over productivies $\alpha \in [a^c, \alpha^*]$. This additional area is dark-shaded and labelled DWL_1 in Figure 3. The large substitution effect induced by increasing marginal returns to education implies the deadweight loss is not a small Harberger triangle; instead the loss can be very large. Of course workers with abilities $a \in [a^S, a^c)$ strictly prefer the no education choice while the socially optimal decision is that they invest to α^S. The corresponding deadweight loss is large.

4.2 Model Summary

Our analysis provides three critical insights. First even if all workers have the same Mincerian return to education (w_0), workers do not have the same marginal return to education - the marginal return to education depends on future expected labor supply which in turn depends on future home productivity. Also there are necessarily increasing marginal returns to education around the non-participant margin (where $\alpha = \alpha_{PT}(b)$). Workers with productivity less than $\alpha_{PT}(b)$ do not participate in the labor market, and so have a zero marginal return to education *ex ante*. Higher productivity workers choose positive labor supply *ex post,* which implies a positive marginal return to education.

The second insight is that, with increasing returns to education, the optimal education decision of an individual with ability a satisfying $MR(a, b_0) < c_0$ is non-marginal. By that we mean the worker compares the payoff to no education (and low labor supply ex-post) against investing to a much higher productivity level $\alpha^*(a, b_0) \gg a$. Proposition 2 shows that this decision is sensitive to expected home productivity, as that determines the relative payoff of non-participation versus working in the market sector.

The third insight is that an increase in tax rates or a more generous social security program reduces the return to working in the labor market and so leads to lower education and participation rates. This is a standard insight. What is non-standard is that the marginal home specialist a^c takes into account the *total* tax taken by the government should the worker instead invest fully in education and work full time. Thus the provision of a social security progam and average tax rates over a range of earnings, rather than a single marginal tax rate, is central to this decision. A marginal analysis does not capture the potential magnitude of the subsititution effect and corresponding deadweight losses.

5 Cross-Country Evidence

The preceding theory describes optimal education choice and labor market participation rates given underlying productivities (a, b) and the tax regime (S, τ). If these underlying abilities are distributed identically across the sexes, the model predicts identical education rates and participation rates by gender. Clearly this is not true empirically. Male participation rates are much higher than female participation rates and, traditionally at least, male education rates are also significantly higher. This outcome can be rationalised by assuming women have higher home productivities than men.[11] An extreme case is that men have $b = 0$ and so participate in the market sector with probability (close to) one. Conversely, depending on their underlying abilities (a, b) and the tax system (S, τ), women partition themselves into either *home specialists* (those with $a < a^c(b; S, \tau)$ who do not invest in education and have low participation rates), or *work specialists* (with $a > a^c(b; S, \tau)$ who invest to productivity $\alpha^* \gg a$ and have high ex-post participation rates). By shifting this partition, tax policy has a potentially large impact on average female education and participation rates.

In this section we assess empirically how the choice of tax regime affects average male and female education and participation rates. We showed in the previous section that there are potentially large deadweight losses due to the tax program. However we also argued that a childcare subsidy, paid to women who have children but work in the labor market, can act as a targeted employment subsidy for women who might otherwise choose to be home specialists. Given the large deadweight loss due to the tax program (S, τ), such targeted subsidies may generate large welfare gains.

A related tax issue is that countries tax second earners differently. In countries in which taxes on second earners are high, second earners will have even lower incentives to work in the market sector and to invest in education. Given that men typically have higher education rates, and assuming that women have higher home productivities, the second earner is likely to be the female partner. High taxes on second earners are then roughly equivalent to raising τ for women, and so are likely to increase the number of female home specialists.[12]

Jaumotte (2004) describes how education rates and participation rates have been changing in OECD countries over the period 1980 to 2001. With the exception of Turkey, all countries have seen an increase in both female participation rates and education rates. The increase in female education rates is small in the most developed OECD countries where female education rates are already high. But there nonetheless remains a significant gap in participation rates. This probably reflects the fact that today's average female participation rates depend on female

[11] This may arise because of cultural factors and gender identity rather than through any biological factors.

[12] Jaumotte (2004) uses panel data for 17 OECD countries spanning the period 1985 to 1999 to investigate the determinants of aggregate labor force participation of women aged 25-54 years. She finds a statistically significant negative correlation between female participation and the wedge between the tax rates of second earners and single individuals (measured at an earnings level of 67% of the average production wage), *ceteris paribus*.

educational choices made over the last 40 years. Since we are unable to take into account such long run changes in educational choices, the reduced form regressions reported below understate the *long-term* effect of a change in tax policy on female labor market participation rates. However, they do show the importance of tax policy.

Using an unbalanced panel of 21 OECD countries over the period 1980 to 2001, we estimate how tax policy affects male and female education rates and participation rates, controlling for country-specific fixed effects.[13] The data were kindly provided by Florence Jaumotte (see Jaumotte (2004) for a full explanation of the construction of the variables), and we augmented them with information on years of education by gender from the Barro and Lee (2000) database.[14] We might anticipate that the country-specific fixed effects for men and women will be positively correlated. For example, if the returns to education are high in the U.S.A., then so too will be education rates for both sexes, as well as resulting participation rates. Conversely we would expect they will be lower in less developed OECD countries.

Figure 4(a) plots female participation rates against male participation rates for each country. The raw data show considerable heterogeneity in female participation rates. Spain, Italy, Ireland and Korea have low female participation rates. The highest female participation rate is in Sweden, closely followed by Iceland, Finland and Denmark. There is considerable heterogeneity in female participation rates, suggesting that country-specific policies and cultural values affecting preferences may well play an important role in affecting female behavior. In constrast, there is much less variation in male participation rates, and the lowest is found in Italy and the highest in Sweden.

It is also interesting to compare male and female years of schooling, illustrated in Figure 4(b), which plots average years of schooling in the female population aged 25 years or more on the vertical axis against the equivalent for men on the horizontal axis. There is a positive correlation between years of schooling for men and women across countries: those countries with high average schooling levels for men also tend to have high levels for women, although

[13] The countries for which we have data are Australia, Austria, Belgium, Canada, Czech, Germany, Denmark, Finland, France, Great Britain, Ireland, Iceland, Italy, Korea, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the USA. The Czech Republic is excluded from the years of education equation.

[14] The education variables are from Barro Lee (2000) at http://www.cid.harvard.edu/ciddata/ciddata.html.. This provides 5-year data points so we interpolated the intervening years.

typically the men are more highly educated.

Figure 5(a) plots female years of education against female participation by country. The raw data suggest a positive correlation between the two across countries, and the fitted line is also illustrated. Figure 5(b) does the same for men and illustrates the much weaker correlation between male years of education and male participation across countries.

5.1 Tax policy and female participation and education

Our theory predicted that higher tax rates reduce the returns from working longer hours, and therefore lead to lower participation rates *and* educational investments. In this section we present separate estimates for female education and participation. The dependent variable for the female education equation is the natural logarithm of the average years of schooling in the female population aged 25 years or more. The dependent variable in the participation equation is the natural logarithm of female labor force participation rates for the age group 25-54 years.

Three explanatory variables proxy tax policy (S, τ). The first variable is the *average tax rate single,* representing the average tax rate net of cash transfers for a single childless person at 67% of the average production wage (APW).[15] The second variable, the *tax wedge 2nd earner,* represents the tax wedge between the second earner (in a two-person household with children) and a single childless person at 67% of APW. A priori, we would expect large tax wedges to reduce female participation and education rates. The third fiscal policy variable, a proxy for income transfer programs, is measured by the index of *child benefits including tax allowances.* This is defined as the increase in household disposable income from child benefits for two children at a gross earnings level of 133% of the APW (of which 33% is earned by the wife).

A fourth explanatory variable is *public spending child care*, which measures state spending on childcare (including formal daycare and preschool expenditures) as a percentage of GDP. As argued above, this can be viewed as an employment subsidy targeted towards younger women. We would therefore expect female participation and education to be responsive to this policy. We also control for the number of children using the variable *number of kids aged 0-14 per*

[15] See Jaumotte (2004) for more details about the variables.Our choice of functional form for these variables was determined after appropriate specification checks.

woman aged 15-64. The means of these variables are given in Table 1.

Table 1: Means of Variables (Pooled OECD Data)

VARIABLE	MEAN
Average tax rate single childless person at 67% APW	24.41
Tax wedge 2nd earner	1.36
Index of child benefits including tax allowances	7.38
Public spending child care as % GDP	0.72
Number of kids aged 0-14 per woman aged 15-64	0.60
Ave years education, female population 25+ yrs	8.80
Female workforce participation, age group 25-54	70.03
Ave years education, male population 25+ yrs	9.43
Male workforce participation, age group 25-54	93.15

Panel A of Table 2 reports separate estimates of the reduced form education and participation equations for women (with t-statistics in parentheses). Our estimated equations also include country-specific fixed effects (FE), with Australia as the base. The explanatory power of both specifications is high, as the reported R^2 reveals. Because average female participation rates depend on female educational choices made over the last 40 years, and female educational choices made in the past likewise depend on anticipated participation rates for particular cohorts, we interpret our results as correlations rather than causations.

First consider years of female education, reported in the first column of results in Panel A of Table 2. *A priori*, we would expect that policies associated with lower tax wedges for second earners, or that act as targeted employment subsidies, would be directly associated with higher female education investment rates, since the returns to market work will be higher. Our estimates for women in Panel A show that this is indeed the case. There is a negative association between the tax wedge and average years of female education, and a positive association between state expenditure on childcare and average years of female education. Both these policy variables are statistically significant at the 1% level. Now consider the estimated coefficient to the variable proxying social security transfers S - child benefits including tax allowances. In the theory section we showed that a more generous social security program reduces the return to working in the labor market and so leads to lower education and participation rates. This is borne out by the regression results, in which the negative association is statistically significant at the 1% level.

Table 2: FE Estimates of Years of Schooling and Participation Rates		
	Yrs. of Education	Participation
A. Women		
Ln average tax rate single	-0.050	-0.063
	(1.14)	(1.79)
Ln tax wedge 2nd earner	-0.253	-0.142
	(3.33)	(2.71)
Ln child benefits & tax allowances	-0.096	0.034
	(3.20)	(1.38)
Public spending child care	0.619	0.201
	(7.77)	(3.11)
Public spending child care squared	-0.144	-0.060
	(6.54)	(3.35)
Ln number of kids	-0.143	-0.843
	(1.76)	(12.92)
Country fixed effects	yes	yes
Adjusted R-squared	0.966	0.967
B. men		
Ln average tax rate single	-0.024	-0.019
	(0.69)	(1.98)
Ln tax wedge 2nd earner	-0.211	0.012
	(3.49)	(0.84)
Ln child benefits & tax allowances	-0.078	0.013
	(3.26)	(1.94)
Public spending child care	0.470	-0.106
	(7.40)	(6.12)
Public spending child care squared	-0.120	0.024
	(6.86)	(5.07)
Ln number of kids	-0.026	-0.053
	(0.40)	(3.01)
Country fixed effects	yes	yes
Adjusted R-squared	0.977	0.737
No. of observations	160	163
No. of countries	20	21

From Proposition 2, we know that $a^c(b)$ is increasing in b. A fall in the number of children might be interpreted as a decline in b, and consequently we would expect female education and participation to increase. Our estimates show that the impact of a decline in the number of children aged 0-14 per woman is indeed associated with an increase in years of female education.

Now consider the estimates for female participation, presented in the last column of Table 2. Female participation is declining in the average tax rate for a single person, although the effect is quite small and statistically significant only at the 10% level. Our estimates also show that tax wedge second earner is associated with lower female participation, as expected. This is significant at the 1% level. The variable public spending child care is associated with an increase in female participation, an effect that is significant at the 1% level.[16] The magnitude of this effect is large. A decline in the number of dependent children per woman can be interpreted as a fall in b.

These findings provide support for our arguments that tax policy and responsibility for childcare affect females' education and labor participation. We next discuss the results for men.

5.2 Tax policy and male participation and education

The dependent variable for the male education equation is the natural logarithm of the average years of schooling in the male population aged 25 years or more. The dependent variable in the participation equation is the natural logarithm of male labor force participation rates for the age group 25-54 years. The estimates are presented in the bottom panel of Table 2.

First consider the results for education, presented in the first column. Tax policy is associated with less education, as also are family cash transfers. Public expenditure on childcare is associated with more years of education, although the magnitude of this effect is smaller than was found for women. The number of dependent children has no statistically significant effect. The explanatory power of this specification is high, with an adjusted R^2 of 0.977.

As anticipated, the results for the male participation model, reported in the second column, are different from the female results. Average tax rates are associated with a significant decline in employment but the tax wedge effect is insignificantly different from zero. Family cash transfers have a positive effect. Our theory suggested a positive effect only if utility is linear in consumption. The child dependency variable has a small negative effect. The explanatory power of this specification is relatively low, with an adjusted R^2 of only 0.737, perhaps reflecting the universality of customs reinforcing male participation in OECD countries.

[16] A further reason to report our results as associations rather than causations relates to political economy factors. In countries with high female participation rates, governments may be more sensitive to female preferences for state-funded childcare, and for this reason childcare and female participation may be positively correlated. Clearly we cannot hope to disentangle such effects with available cross-country data.

5.3 Discussion

Figures 4 and 5 showed that there are big differences across countries in female participation rates and in male and female years of education. These differences are explained to a large degree by our policy variables and the proxy for fertility, as well as by the country fixed effects, although the controls were less able to explain male participation rates. A plot of the regression-adjusted country fixed effects from the female education equation against the regression-adjusted country effects from the female participation equation (available from the authors on request) indicated that countries with high female education also tend to have high female participation even after controlling for tax policy and fertility. This suggests that country-specific factors that we are unable to control for - such as returns to education and cultural values - play an important role. Portugal, New Zealand, the USA and Canada have very similar participation rates after controlling for tax policy and fertility, but women in Portugal have very much lower levels of education. Sweden, even after controlling for tax policy and fertility, has relatively high female education and the highest level of participation. Iceland, with similar participation, has lower education. Italy and Spain are characterized by both low education and low participation. The comparable plot for men showed no such pattern of positive correlation between male education and participation after controlling for policy. Indeed, there is a slightly negative relationship between education and male participation.

Given the recent debate in the macroeconomic literature, which has focused in particular on US and Sweden, we next calculate what US participation and education would look like if the US had Swedish policies. We therefore use the estimates reported in Table 2 to show predicted labor force participation and years of education for the USA. The first row of Table 3 gives these predictions for US women (74% participation and just under 12 years of education), while the seventh row gives the predictions for US men (93% participation and just over 12 years of education). The other rows of Table 3 shows how these predictions change as policies are altered to Swedish values. Thus the second row shows how female participation and education would increase if the US were to lower its tax wedge for second earners to the Swedish value. Such a policy shift would increase female partcipation by around 3 percentage points to 77%. Female years of education would rise to 12.6. Row [3] shows the combined effects of adopting

Swedish tax policy as summarised by the two variables average tax rate single and tax wedge second earner.[17] Predicted participation in the USA when Swedish tax policy is introduced is 76%. This is a net increase because the negative effect of shifting to a higher average tax rate is outweighed by the positive effect of shifting to a lower tax wedge on second earners.

Table 3: Comparative Statics for Predicted US Participation and Education

	Comparative static changes	Participation (%)	Education (yrs)
	A. WOMEN		
[1]	All US values	73.98	11.73
[2]	US with Swedish tax wedge 2nd earner	76.87	12.56
[3]	US, both Swedish tax policy variables	75.90	12.44
[4]	US, with Swedish child benefits & tax allowance	71.87	10.80
[5]	US with Swedish childcare expenditures	81.88	18.71
[6]	US with Swedish child dependency rates	83.33	11.97
	B. MEN		
[7]	All US values	92.81	12.11
[8]	US with Swedish tax wedge 2nd earner[18]	92.52	12.82
[9]	US, with Swedish child benefits & tax allowance	92.16	12.76
[10]	US, with Swedish tax policy	93.83	11.32
[11]	US, with Swedish childcare expenditures	85.53	16.54
[12]	US, with Swedish child dependency rates	93.50	12.07

Row [4] of Table 3 shows what happens when we restore tax policy to US values and instead change the index for family cash transfers from the average US value of 4.1 to the average Swedish value of 9.8. As shown, predicted years of education drop to 10.8 and participation declines to 72%, although the latter is not statistically significant. Next, Row [5] shows what happens when US public childcare expenditure as a percentage of GDP is increased to match Swedish rates.[19] It can be seen that US female participation increases to almost 82% while its years of education increase to over 18. While the latter is arguably an overprediction, it does emphasise the importance of state childcare expenditures as a targeted subsidy.[20] Row [6] of

[17] The US value for the average tax rate single is 22.16 while for Sweden it is much higher, at 29.6. However the tax wedge is higher in the US at 1.33, while it is much lower at 1.0 in Sweden.

[18] Note however that the tax wedge has an insignificant effect on male participation rates, while the average tax rate and the number of dependent children have an insignificant effect on male years of education (see Table 2, Panel B).

[19] This involves a shift from just 0.474% to 1.8753%.

[20] Such expenditures might also have the additional effect of improving the human capital of children, as argued recently by the UK Government, but that is a separate issue not considered here.

Table 3 shows what happens when the US retains all its policy values but shifts to Swedish child dependency rates (a decline from 0.66 to 0.58). Now US female participation is 83% while average years of female education are 12. The results for US men, from a similar comparative static exercise, are reported in Panel B of Table 3. This counterfactual exercise suggests that it is not really a puzzle that Sweden is characterized by both high average tax rates and high labor supply. There are other important policies affecting female labor supply and education that can explain the coexistence of high average tax rates and high labor supply.

6 Conclusion

This paper has considered optimal educational investment and labour supply assuming increasing returns in the earnings function. Individual labour market responses to tax policy are shown to be sensitive to home productivity. Specifically, increasing returns implies a tax on labour income can generate large, non-marginal substitution effects, driving those with a comparative advantage in home production out of the labour market. Assuming home productivity varies substantially between the genders, the model predicts individual responses to fiscal policy will vary significantly across men and women.

Consistent with the theory, our empirical results indicate that gender differences in labor supply responses to tax policy can play an important role in explaining differences in aggregate labor supply across countries. Our estimates show that female participation and female years of education are significantly declining in the tax wedge for second earners and significantly increasing in public expenditure on childcare. Female years of education are significantly declining in income transfers as proxied by child benefits but participation is unaffected. In summary, while high tax rates - especially on second earners - encourage women to switch from market to home production, these distortions can be partically offset by targeted employment subsidies such as state-funded childcare. Our analysis suggests that the co-existence in Sweden of high average tax rates and high labor supply, viewed in recent macroeconomic studies as a puzzle, is in fact consistent with the observation that labor supply responses and educational investments vary by gender in response to heterogeneity in family-related fiscal policies.

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7 Appendix

Proof of Claim 2.

The definition of b_{FT} and CRRA implies

$$b_{FT} = \alpha(1-\tau)w_0(S + (1-\tau)\alpha)^{-\sigma}/x'(0).$$

Differentiating with respect to α yields

$$\frac{\partial b_{FT}}{\partial \alpha} = \frac{(1-\tau)w_0[S + (1-\sigma)(1-\tau)w_0\alpha]}{(S + (1-\tau)w_0\alpha)^{\sigma+1}x'(0)}$$

and so

$$\frac{\partial b_{FT}}{\partial \alpha} \gtreqless 0 \text{ as } S + (1-\sigma)(1-\tau)w_0\alpha \gtreqless 0.$$

For $b \in (b_{FT}, b_{PT})$, (3) implies $\partial l^*/\partial \alpha$ is given by

$$\frac{\partial l^*}{\partial \alpha} = \frac{(1-\tau)w_0}{-bx'' - \alpha^2(1-\tau)^2 w_0^2 u''}[u'(y_{PT}) + \alpha(1-\tau)w_0 l^* u''(y_{PT})]$$

where $y_{PT} = S + (1-\tau)\alpha w_0 l^*$. Concavity of x and u implies $\partial l^*/\partial \alpha > 0$ if and only if $u'(y_{PT}) + \alpha(1-\tau)w_0 l^* u''(y_{PT}) > 0$. CRRA now implies

$$\frac{\partial l^*}{\partial \alpha} \gtreqless 0 \text{ as } S + (1-\sigma)(1-\tau)\alpha w_0 l^* \gtreqless 0, \tag{6}$$

where $b \in (b_{FT}, b_{PT})$ implies $l^* \in (0, 1)$.

The statement of the Claim follows from these facts and (a) l^* is strictly decreasing in b for $b \in (b_{FT}, b_{PT})$, (b) $l^* = 1$ at $b = b_{FT}$ and (c) $l^* = 0$ at $b = b_{PT}$. b^c is defined where $S + (1-\sigma)(1-\tau)w_0\alpha l^* = 0$.

Proof of Proposition 2. Recall V is defined by

$$V(a, b) = \int_a^{\alpha^*} (MR(\alpha, b) - c_0)\, d\alpha$$

and a^c is then defined by the implicit function $V(a^c, b) = 0$. Differentiating $V(.)$ with respect to b, noting that $MR(\alpha^*, b) = c_0$, yields

$$\frac{\partial V}{\partial b} = \int_a^{\alpha^*} \frac{\partial\,[MR(\alpha, b)]}{\partial b} d\alpha.$$

Now (5) implies $\partial[MR]/\partial b = 0$ outside of the part-time region. In the part-time region $\alpha \in (\alpha_{PT}, \alpha_{FT})$, (3) in Claim 1 implies that l^* is strictly decreasing in b. Further CRRA with $\sigma \leq 1$ implies

$$\frac{\partial}{dl^*}[l^* u'(S + (1-\tau)\alpha w_0 l^*)] = \frac{S + (1-\sigma)(1-\tau)\alpha w_0 l^*}{[S + (1-\tau)\alpha w_0 l^*]^{\sigma+1}} > 0.$$

(5) and $\sigma < 1$ now imply $\partial[MR]/\partial b < 0$ in the part-time region. Hence we have $\partial V/\partial b < 0$. As the proof of Proposition 1 implies $\partial V/\partial a > 0$ at $a = a^c$, the Implicit Function Theorem implies a^c increases with b.

Proof of Proposition 3. In the extended notation, V is defined by

$$V(a, b; S, \tau) = \int_a^{\alpha^*} (MR(\alpha, b; S, \tau) - c_0)\, d\alpha.$$

and a^c is given by the implicit function $V(a^c, b; S, \tau) = 0$. Differentiating V wrt S, noting that $MR(\alpha, b; S, \tau) = c_0$ at α^*, yields

$$\frac{\partial V}{\partial S} = \int_a^{\alpha^*} \frac{\partial\,(MR(\alpha, b; S, \tau.))}{\partial S} d\alpha.$$

Now (5) with $\sigma < 1$ implies MR does not change with S in the non-participant region (it is zero) and is strictly decreasing in S in the part-time[21] and full-participation regions. Hence $\partial V/\partial S < 0$. As $\partial V/\partial a > 0$ at $a = a^c$, the Implicit Function Theorem implies a^c increases with S.

Similarly

$$\frac{\partial V}{\partial \tau} = \int_a^{\alpha^*} \frac{\partial\,(MR(\alpha; b_0, S, \tau.))}{\partial \tau} d\alpha.$$

[21] For $\alpha \in (\alpha_{PT}, \alpha_{FT})$, (3) implies l^* decreases with S while total earnings, $S+(1-\tau)\alpha w_0 l^*$ increase. Together these imply that MR falls within the part-time region.

(5) with $\sigma < 1$ again implies MR does not change in the non-participant region (it is zero) and is strictly decreasing in τ in the part-time and full participation regions. Hence a^c increases with τ. This completes the proof of Proposition 3.

Figure 1: Labor Supply

Figure 1a: ($\sigma < 1$)

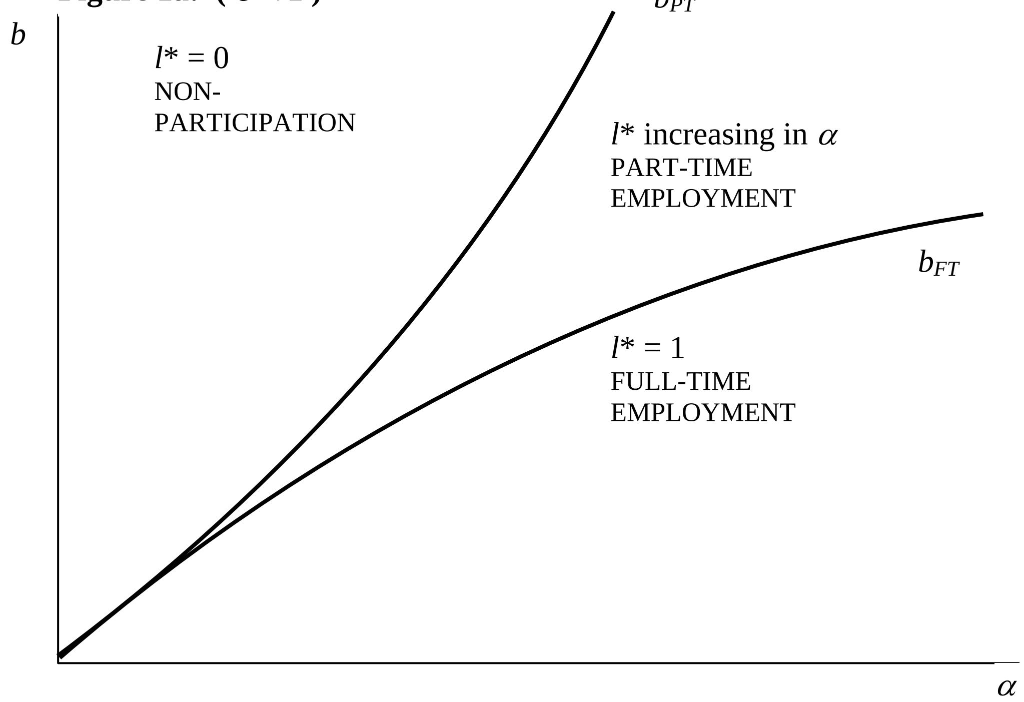


Figure 1b: ($\sigma > 1$)

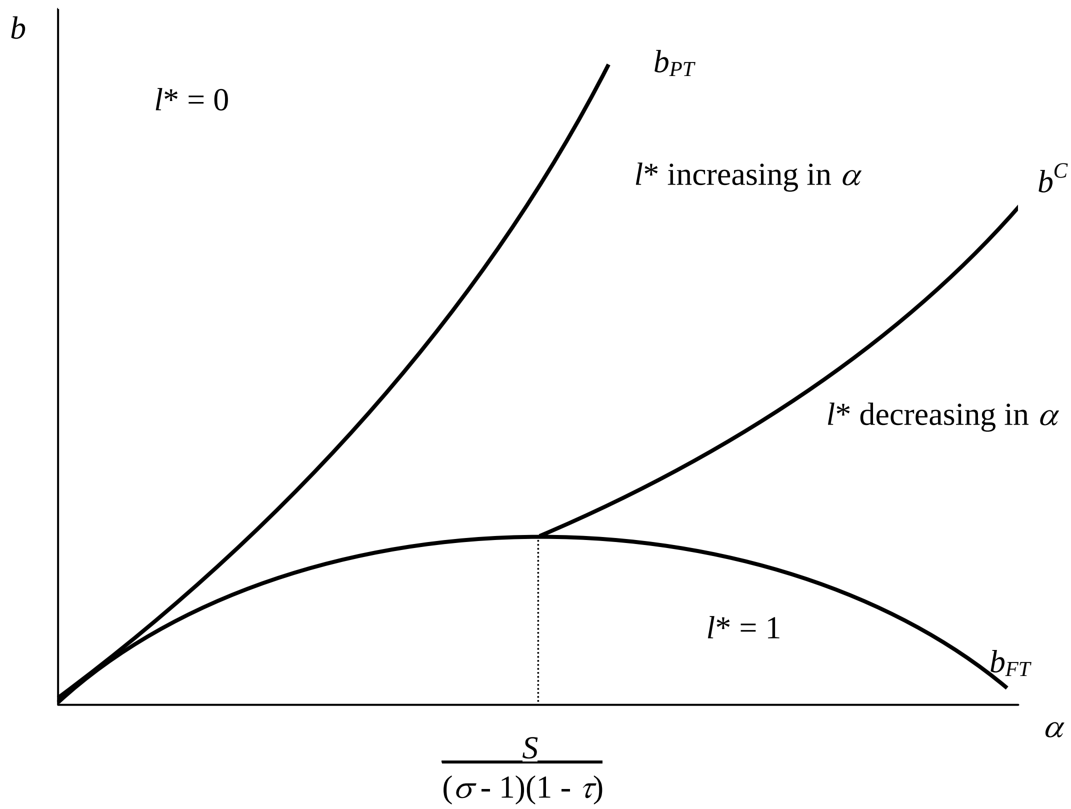


Figure 2: Optimal Education Choice (b_0 given)

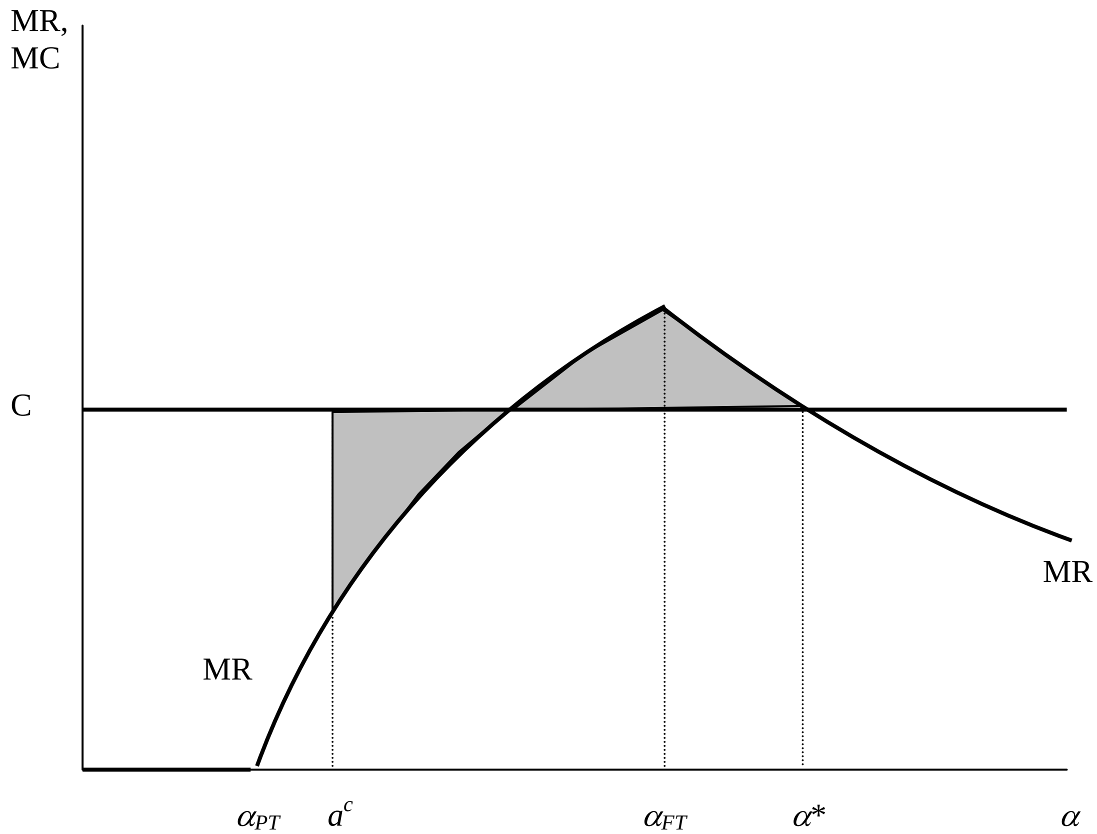
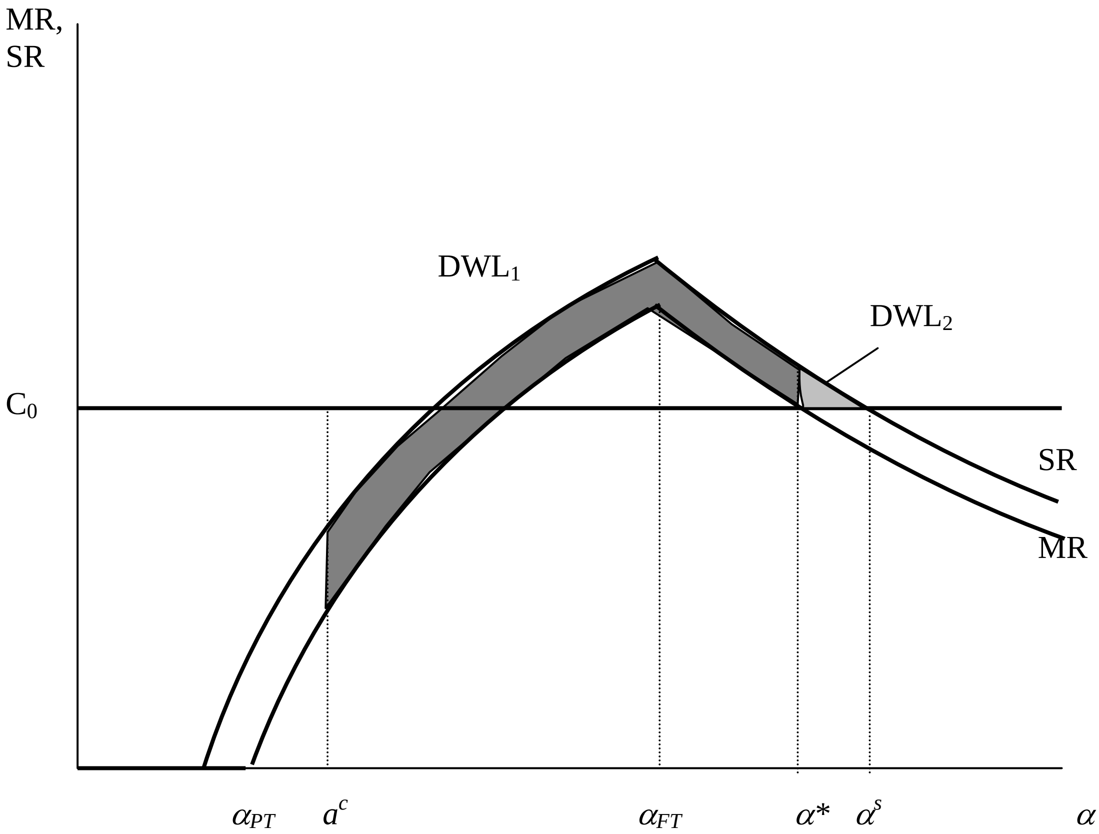


Figure 3: Deadweight Losses



Fig, 4a: Raw Female and Male Participation Rates

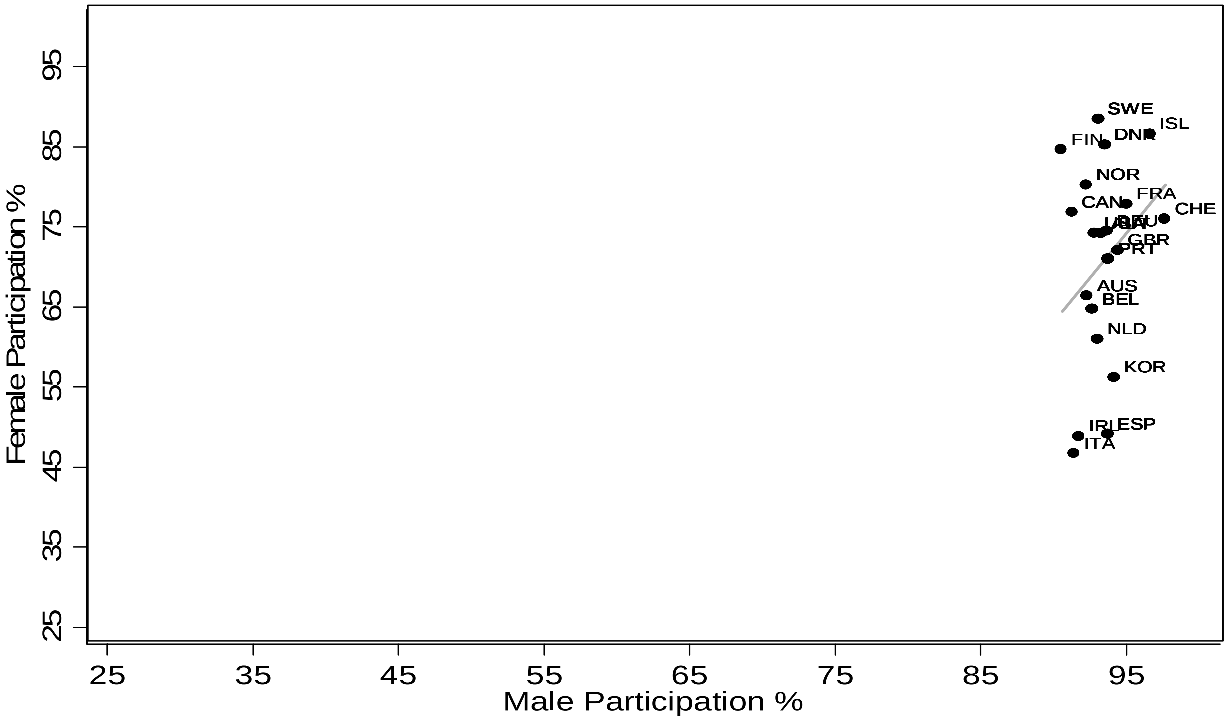


Fig. 4b: Raw Data, Female and Male Years of Education

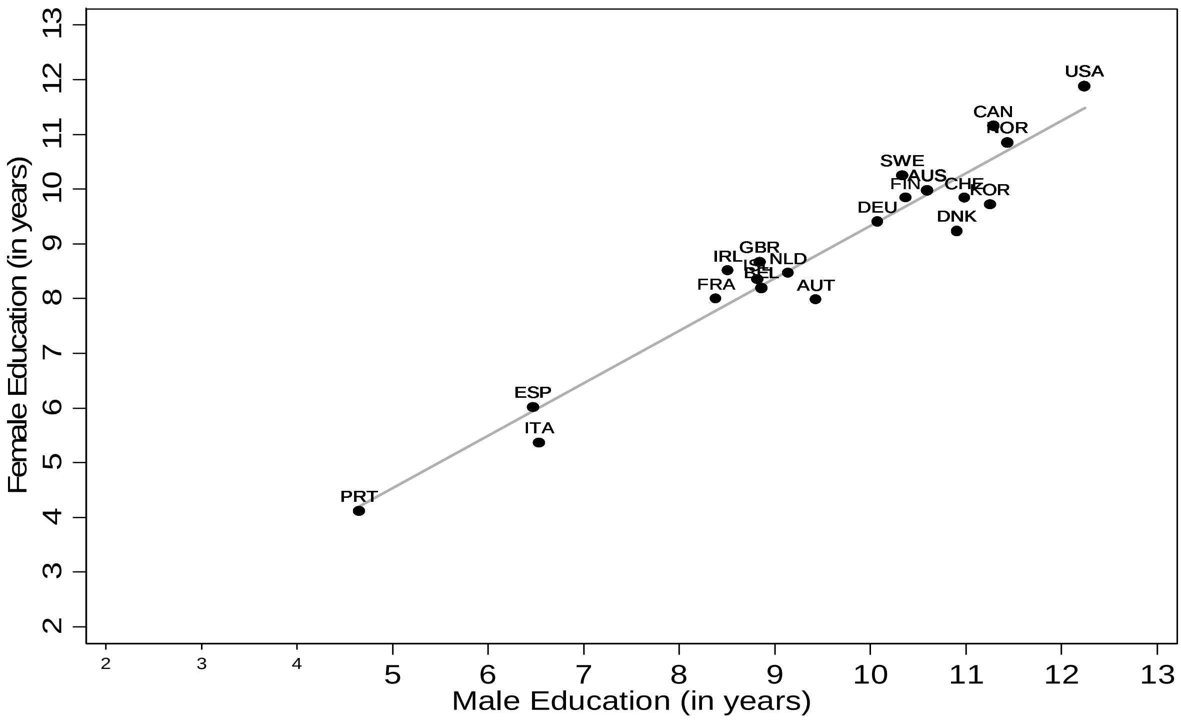


Fig. 5a: Raw Data, Female Years of Education and Participation Rates

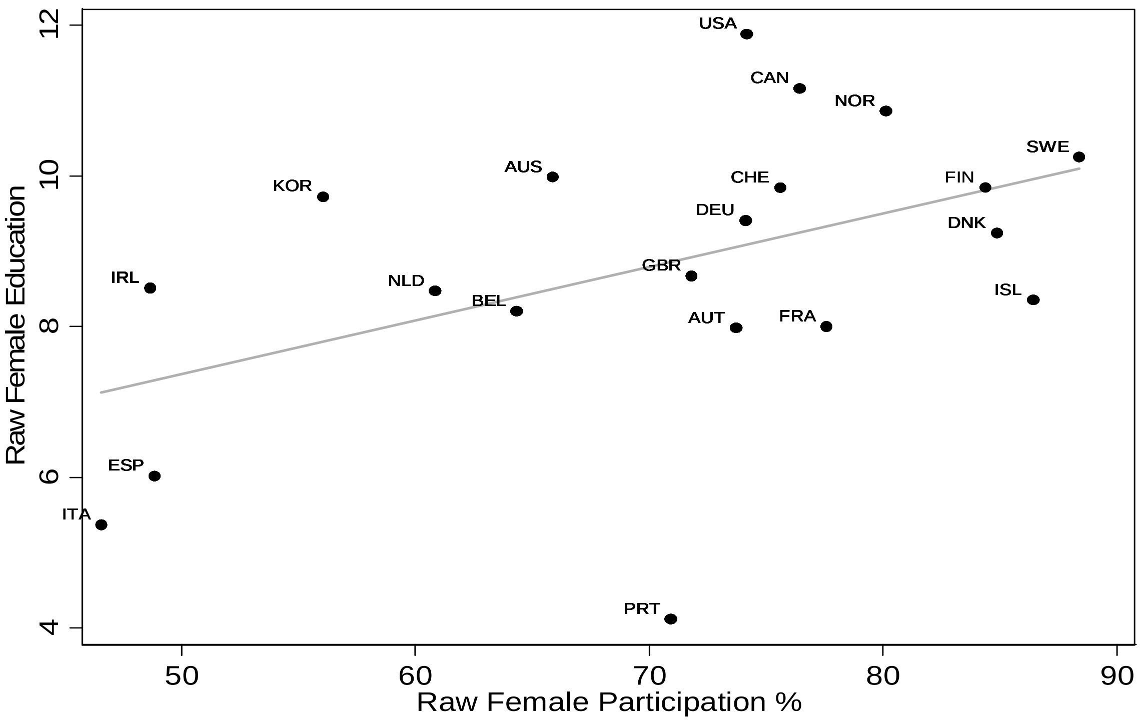


Fig. 5b: Raw Data, Male Years of Education and Participation Rates